NBS SPECIAL PUBLICATION 443

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Hydraulic Research in the United States and Canada, 1974

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[2] Located at Boulder, Colorado 80302.

Hydraulic Research in the United States and Canada, 1974

Edited by

Gershon Kulin and Pauline H. Gurewitz

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National Bureau of Standards
Washington, D.C. 20234

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Issued June 1976

Library of Congress Catalog Card Number: 73-60019

National Bureau of Standards Special Publication 443
Nat. Bur. Stand. (U.S.), Spec. Publ. 443, 359 pages (June 1976)
CODEN: XNBSAV

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1976

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Catalog No. C13.10:443). Price $4.15 (Add 25 percent additional for other than U.S. mailing).

ABSTRACT

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1973-1974 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

Key words: Fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

PREFACE

This publication first appeared in 1933 as "Hydraulic Research in the United States" in answer to a need to keep hydraulicians aware of pertinent current activity in research laboratories throughout the United States and Canada. With the exception of a few World War II years, it was published annually through 1966, after which publication became biennial. In 1972 the title was changed to "Hydraulic Research in the United States and Canada."

The National Bureau of Standards appreciates the cooperation of the more than 200 organizations which have contributed to this issue their summaries of hydraulic and hydrologic research and of other fluid mechanics research of interest and usefulness to hydraulicians. These reporting organizations are listed beginning on page vii. Although efforts are made to solicit reports from all laboratories whose work comes to our attention, the National Bureau of Standards cannot assume responsibility for the completeness of this publication. We must depend in the last analysis upon reporting laboratories for the completeness of the coverage of their own programs, and upon new laboratories engaged in pertinent research to bring their activities to our attention.

Detailed information regarding the research projects reported here should be obtained from the correspondent listed under (c) or immediately following the title and address of the organization reporting the work. The National Bureau of Standards does not maintain a file of publications, reports or other detailed information on research projects reported by other laboratories. It is of course understood that laboratories submitting reports on their work will be willing to supply additional information to properly qualified inquirers.

Readers of "Hydraulic Research in the United States and Canada" can find related information in the "Water Resoruces Research Catalog," prepared by the Science Information Exchange of the Smithsonian Institution for the Office of Water Resources Research, U. S. Department of the Interior. Information on that publication can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. (See also Key to Projects on next page.)

CONTENTS

KEY TO PROJECTS

The project summaries are grouped in three sections: (1) U. S. university, state and industrial laboratories, (2) U. S. Government laboratories, and (3) Canadian laboratories. Within each section the source laboratories are listed alphabetically (see List of Contributing Laboratories on page vii) and are numbered sequentially using the first three digits of the identification number.

(a) Project number and title
In the thirteen-digit identification number, e.g., 129-01111-000-00, preceding each title, the second (five-digit) group, e.g., 01111, is the project number. Once assigned, this number is repeated in each issue for identification purposes until the project is completed. In this issue the numbers 08653 and above are projects being reported for the first time. Projects with numbers lower than 08653 can be found in earlier (through 1970) issues with the zero deleted, e.g. (1111). Numbers followed by W, e.g. 0122W, identify projects which are included here by title only and are completely summarized in "Water Resources Research Catalog." See Preface.

(b) Project conducted for
Only out-of-house sponsors are listed here. Absence of an entry indicates in-house support.

(c) Correspondent
Where there is no entry here, refer to the correspondent cited directly following the title and address of the reporting laboratory.

(d) Nature of Project
Basic or applied; theoretical, experimental; thesis, etc.

(e) Description of Project

(f) Present status
Absence of an entry here implies that the project was in an active status at time of submission.

(g) Results
In many continuing projects this section contains only results obtained since the previous issue of "Hydraulic Research in the United States and Canada." For completeness, readers are encouraged to consult earlier issues and/or publications listed under (h).

(h) Publications

For the continuing projects, only publications since the last issue are generally listed. Older publications are listed when there have been no new publications since the last issue or when a project is being reported for the first time. For completeness, readers are encouraged to consult earlier issues.

LIST OF CONTRIBUTING LABORATORIES

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U. S. GOVERNMENT AGENCIES

- - - - - - - - - -

CANADIAN LABORATORIES Page

- - - - - - - - - -

PROJECT REPORTS FROM UNIVERSITY, STATE, AND INDUSTRIAL LABORATORIES

ADVANCED TECHNOLOGY CENTER, INCORPORATED (Formerly LTV Research Center), P. O. Box 6144, Dallas, Tex. 75222. Dr. F. W. Fenter, President and Chairman of the Board.

001-08653-250-20

DIFFUSION OF ADDITIVES

(*b*) Office of Naval Research.
(*c*) Dr. C. S. Wells, Jr.
(*d*) Theoretical and experimental; basic research.
(*e*) Evaluate the effects of high molecular weight polymers on turbulent diffusion in boundary layer flows. This will permit the prediction of skin friction reduction and boundary layer separation for flows with polymer additives.
(*g*) Effects of additive diffusion on skin friction reduction documented; study of effects on separation continuing.
(*h*) **Drag-Reducing Polymer Molecular Weight Effects on Turbulent Diffusion for Uniformly Distributed Polymer Injection,** R. R. Walters, *Advanced Technology Center, Inc. Report No. B-94300/4CR11*, Mar. 1974.

AEROSPACE CORPORATION, P.O. Box 92957, Los Angeles, Calif. 90009. Dr. A. Mager, President and General Manager, Engineering Science Operations.

002-07917-050-00

STUDIES OF SWIRLING FLOWS

(*d*) Theoretical; applied research.
(*e*) Investigation of free and confined swirling flows with particular emphasis on the breakdown phenomena.
(*h*) **Steady, Incompressible, Swirling Jets and Wakes,** A. Mager, *AIAA J.* **12,** 11, 1974.

UNIVERSITY OF AKRON, Department of Chemical Engineering, Akron, Ohio 44325. Department Head.

003-07918-270-40

BIOMEDICAL IMPLICATIONS OF DRAG REDUCING AGENTS

(*b*) National Heart and Lung Institute.
(*c*) Drs. H. L. Greene, R. A. Mostardi, R. F. Nokes, L. C. Thomas, c/o Institute for Science and Engineering Research.
(*d*) Theoretical and experimental investigation involving basic and applied research. Some parts of the project have been undertaken as Masters and Doctoral theses.
(*e*) Research has been undertaken to investigate possible hydrodynamic and biological effects of soluble polymeric substances (drag reducing agents or DRA) on vascular blood flows. Possible relationships between vascular turbulence, atherogenesis, and fluid viscoelasticity have been examined both *in vivo* and *in vitro*.
(*g*) Major results to date indicate, firstly, that drag reduction occurs predictably in blood with DRA addition. Secondly, large reductions (~ 50 percent) in erythrocyte trauma during extracorporeal pumping occur with addition of DRA, probably because of viscoelastic lessening in the turbulent disturbances generated by such pumps. Thirdly, preliminary animal experiments suggest that DRA may inhibit hydrodynamic damage in the vascular system, resulting in significant diminution of arterial disease.

UNIVERSITY OF AKRON, Department of Mechanical Engineering, Akron, Ohio 44325. Dr. Rudolph J. Scavuzzo, Department Head.

004-08654-010-14

DEVELOPMENT OF A METHOD FOR COMPUTING SUBSONIC AND TRANSONIC SEPARATED FLOWS

(*b*) U. S. Army Research Office, Durham.
(*c*) Dr. Philip M. Gerhart, Asst. Professor.
(*d*) Analytical, applied research.
(*e*) A method of computation of separating and separated turbulent boundary layers in flows from incompressible through transonic speed range is under development. Primary emphasis is placed on determination of resulting pressure distribution and integral boundary layer parameters.

004-08655-090-00

ANALYSIS OF THE REATTACHMENT OF A TWO-DIMENSIONAL TURBULENT SHEAR LAYER

(*c*) Dr. P. M. Gerhart, Asst. Professor; A. Schaeper.
(*d*) Analytical, basic research for M.S. thesis.
(*e*) The flow in the vicinity of a two-dimensional turbulent reattachment will be considered. The concept of stagnation of an inviscid but rotational fluid layer will be investigated.

004-08656-250-41

BIOMEDICAL IMPLICATIONS OF DRAG REDUCING AGENTS

(*b*) HEW.
(*c*) L. C. Thomas, Assoc. Professor.
(*d*) Experimental and theoretical.
(*g*) The potential usefulness of drag reducing agents in medical applications has been demonstrated.
(*h*) **Turbulence Studies for Steady and Pulsed Flow of Drag Reducing Solutions,** L. C. Thomas, H. L. Greene, R. F. Nokes, M. Chu, *72nd Natl. AIChE Mtg.*, St. Louis, Mo., 1972, *AIChE Symp. Series* **130,** 69, 14, 1973.
An Experimental and Theoretical Study of the Viscous Sublayer for Turbulent Tube Flow, L. C. Thomas, H. L. Greene, *Symp. on Turbulence in Liquids*, Univ. of Missouri, Rolla, 1973.
The Effect of Drag Reducing Additives on Turbulent Pulsatile Flow, L. C. Thomas, R. K. Shukla, H. L. Greene, *ASME Winter Ann. Mtg.*, 1974.
Measurement of Internal Wall Turbulence and Its Relationship to Other Genesis, R. A. Mostardi, R. F. Nokes, H. L. Greene, L. C. Thomas, *27th ACEMB*, Philadelphia, 1974.
Review of Potential Biomedical Applications of Drag Reducing Agents, H. L. Greene, L. C. Thomas, R. A. Mostardi, R. F. Nokes, *1st Intl. Conf. on Drag Reduction*, Cambridge, England, 1974.

004-08657-140-54

TURBULENT CONVECTION TRANSPORT

(*b*) NSF.
(*c*) L. C. Thomas, Assoc. Professor.
(*d*) Theoretical and experimental, basic research for Ph.D., M.S. thesis.
(*e*) Development and application of surface renewal approach to turbulent transport processes.
(*g*) This approach has been successfully adapted to a broad range of turbulent transport processes including both boundary layer and internal flows.
(*h*) **Effect of Viscous Dissipation on Turbulent Forced Convective Heat Transfer,** B. T. F. Chung, L. C. Thomas, *J. Heat Transfer, Trans. ASME* **95,** 562, 1973.
Predictions of Heat Transfer for Turbulent Boundary Layer with Pressure Gradient, P. M. Gerhart, L. C. Thomas, *AIAA J.* **11,** 552, 1973.
Adaptation of the Stochastic Formulation of the Surface Rejuvenation Model to Turbulent Convective Heat Transfer, R. Rajagopal, L. C. Thomas, *Chem. Eng. Sci.* **29,** 1639, 1974.
A Surface Renewal Based Formulation for Turbulent Boundary Layer Flow, L. C. Thomas, *AIAA*, in press, 1974.
A Surface Renewal Based Analysis for Hydrodynamic Unsteady Convection Heat Transfer, L. C. Thomas, *Can. J. Chem. Eng.*, in press, 1974.
Adaptation of the Surface Renewal Approach to Momentum and Heat Transfer for Turbulent Pulsatile Flow, L. C. Thomas, *J. Heat Transfer, Trans. ASME* **96,** 348, 1974.
A Model of Turbulent Momentum and Heat Transfer at Points of Separation or Reattachment, P. M. Gerhart, L. C. Thomas, *Proc. HTFMI* **122,** 1974.
The Formulation of Relationships for ϵ_m and ϵ_H Based on a Physically Realistic Model of Turbulence, R. Rajagopal, L. C. Thomas, *5th Intl. Heat Transfer Conf.*, Japan, 1974.

ARIZONA STATE UNIVERSITY, Department of Chemical and Bio Engineering, Tempe, Ariz. 85281. Dr. Castle O. Reiser, Faculty Chairman.

005-08825-250-00

DRAG REDUCING ADDITIVES

(*c*) Dr. Neil S. Berman.
(*d*) Experimental and theoretical basic and applied research.
(*e*) Study of the relationship of flow timescales to high molecular weight polymer solution timescales.
(*g*) Experiments have been conducted showing the effect of molecular weight distribution, time scale distribution and different irrotational and turbulent flow scales.
(*h*) **Onset of Drag Reduction in Dilute Polymer Solutions,** N. S. Berman, W. K. George, Jr., *Phys. Fluids* **17,** 250, 1974.
Time Scale and Molecular Weight Distribution Contributions to Dilute Polymer Solution Fluid Mechanics, N. S. Berman, W. K. George, Jr., *Proc. 1974 Heat Transfer and Fluid Mech. Inst.*, Stanford Univ. Press, 1974, pp. 348-364.
Dilute Polymer Solution Pressure Hole Errors in Turbulent Boundary Layers, N. S. Berman, G. B. Gurney, *AIChE J.* **20,** 2, Mar. 1974, pp. 393-394.

005-08826-170-33

EFFECT OF SURFACE FILMS ON WAVES AND EVAPORATION

(*b*) Office of Water Resources Research.
(*c*) Dr. C. O. Reiser.
(*d*) Experimental and theoretical, basic and applied research, M.S. theses.
(*e*) Effect of surface films on waves and evaporation reduction. Modeling and simulation of reservoirs to predict evaporation reduction by surface films. See also WRRC, Vol. 8, 3.0016.
(*f*) Wind tunnel tests being undertaken to compare effectiveness of films in wave suppression.

ARIZONA STATE UNIVERSITY, Department of Mechanical Engineering, Tempe, Ariz. 85281. Dr. Darryl Metzger, Department Chairman.

006-07141-000-00

LAMINAR FLOW BETWEEN CO-ROTATING DISKS

(*d*) Analytical and experimental; applied research; Doctoral and MSE theses.
(*e*) Development of solutions for flow useful in development and design of multiple-disk turbomachinery; experimental investigation of criteria for transition of laminar to turbulent flow, and experimental confirmation of analytical descriptions earlier obtained.
(*g*) Production of design maps for multiple-disk turbomachinery; data obtained experimentally for determining criteria for transition from laminar to turbulent flow between co-rotating disks; experimental determination of streamlines for wide range of operational parameters for such flows.
(*h*) **Flow Regime Definition for Flow Between Co-Rotating Disks,** L. L. Pater, E. Crowther, W. Rice, *J. Fluids Engrg., ASME Trans.* **96,** Series 1, 1, Mar. 1974, pp. 29-34.
Transition of Inward Flow Between Closely-Spaced Parallel Co-Rotating Disks, *Ph.D. Dissertation*, Mech. Engrg., Ariz. State Univ., Tempe, Ariz., Jan. 1973.
An Experimental Investigation of Outward Flow of an Incompressible Newtonian Fluid Between Closely-Spaced Parallel Co-Rotating Disks, *MSE Thesis*, Mech. Engrg., Ariz. State Univ., Tempe, Ariz., May 1973.
Calculated Design Data for the Multiple-Disk Pump Using Incompressible Fluid, M. E. Crawford, W. Rice, *J. of Engrg. for Power, ASME Trans.* **96,** Series A, 3, July 1974, pp. 274-282.
Calculated Design Data for the Multiple-Disk Turbine Using Incompressible Fluids, *ASME publication 74-FE-9.*

006-08696-000-00

STABILITY OF SPIRAL FLOW IN A ROTATING ANNULUS

(*c*) Professor D. F. Jankowski.
(*d*) Experimental and theoretical; basic research; Doctoral thesis.
(*e*) Investigation of the influence of an axial flow on the linear stability of flow between rotating cylinders for the wide gap case.
(*g*) Incomplete.

006-08697-210-00

STEADY TURBULENT FLOW IN A DUCT OF ARBITRARY CROSS-SECTION

(*c*) Professor Warren Rice.
(*d*) Theoretical; applied research.
(*e*) Formulation of a computer-oriented calculation procedure for the velocity field in a turbulent flow in a duct of arbitrary cross-sectional shape, for which the pressure gradient is known.
(*g*) Incomplete.
(*h*) Manuscript in preparation.

006-08698-630-00

INVESTIGATION OF AN UNCONVENTIONAL HYDRAULIC GAS COMPRESSOR (TROMPE COMPRESSOR)

(*c*) Professor Warren Rice.
(*d*) Experimental and analytical; basic and applied; Masters thesis.
(*e*) The compressor involves gas bubbles being carried downward in a column of liquid. An analytical model of the compressor involving this type of two-phase flow has been made and calculations of the expected performance

have been made using a digital computer. The analytical model has been compared with data from an experimental model of the compressor with excellent agreement.

(*g*) Incomplete.

—

UNIVERSITY OF ARIZONA, Department of Aerospace and Mechanical Engineering, Tucson, Ariz. 85721. Dr. L. B. Scott, Head.

007-08718-090-54

NUMERICAL PREDICTIONS FOR UNSTEADY VISCOUS AERODYNAMICS

(*b*) National Science Foundation.
(*c*) R. B. Kinney, Assoc. Professor.
(*d*) Theoretical; basic research (Ph.D. thesis).
(*e*) Develop a numerical and semianalytical method for predicting the unsteady viscous flow about aerodynamic shapes started from rest in an infinite and incompressible fluid. Departing markedly from conventional approaches used to solve the Navier-Stokes equations, the present method makes extensive use of kinematical relationships common to inviscid aerodynamic analyses. The aerodynamic shape is replaced by a suitable "bound" vortex distribution which allows the velocity field to satisfy the viscous adherence condition at all points on the solid surface. Reducing the tangential slip velocity to zero at the surface causes vorticity to be created at the surface. This "free" vorticity enters the fluid by transverse diffusion and is ultimately transported throughout the fluid surrounding the body. The complete flow field is obtained by simultaneously solving the full transport equation for the "free" vorticity in the fluid, the equation for the "bound" vortex distribution on the surface, and the velocity components as given by the law of induced velocities (Biot-Savart Law).
(*g*) The method was first applied to flat-plate shapes impulsively started from rest. Only the two-dimensional flow field was calculated (see (h)). Currently, the two-dimensional flow past a Joukowski airfoil of appreciable thickness is being studied.
(*h*) **Flow Transient Near the Leading Edge of a Flat Plate Moving Through a Viscous Fluid,** R. B. Kinney, M. A. Paolino, *J. Applied Mech.* **41**, 4, pp. 919-924, 1974.
Numerical Study of Unsteady Viscous Flow Past a Lifting Plate, R. A. Schmall, R. B. Kinney, *AIAA J.* **12**, 11, pp. 1566-1573, 1974.

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UNIVERSITY OF ARIZONA, College of Agriculture, Department of Soils, Water and Engineering, Tucson, Ariz. 85721. Dr. K. K. Barnes, Department Head.

008-0266W-820-60

GROUNDWATER SUPPLIES

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0033.

008-0267W-840-33

MODELING SOIL WATER MOVEMENT FOR TRICKLE IRRIGATION

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0035.

008-0268W-820-07

MEASUREMENT, PREDICTION AND CONTROL OF SOIL WATER MOVEMENT IN ARID AND SEMI-ARID SOILS

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0036.

008-0269W-840-07

SURFACE IRRIGATION FLOW ANALYSIS THROUGH MODEL STUDIES

(*e*) For summary, see Water Resources Research Catalog **9**, 3.0011.

—

AVCO EVERETT RESEARCH LABORATORY, INCORPORATED, 2385 Revere Beach Park, Everett, Mass. 02149. Arthur Kantrowitz, Chairman of the Board.

009-09086-270-40

BLOOD FLOW

(*b*) National Institute of Arthritis, Metabolism and Digestive Diseases.
(*c*) Asst. to the Chairman, Raymond B. Janney II.
(*d*) Experimental; applied.
(*e*) See (g) below.
(*f*) Completed.
(*g*) The formation of platelet aggregates which embolize to the peripheral circulation has previously been noted as a significant deleterious effect resulting from both intra- and extracorporeal artificial circulatory devices. Utilizing the stagnation flow experiment which permits visualization during flow of aggregate formation on first contact of blood with an artificial surface, the formation of freely floating aggregates has been observed in separated flow regions. Embolization from the separated flow has also been observed. Comparison of observed growth rates with a hydrodynamic model suggests that sufficient activation has occurred within the separated region so that platelets stick on virtually every collision. Some criteria have also been suggested which correlate with the flow conditions under which aggregate formation does or does not occur. At high flow rates where freely floating aggregates do not form, significant surface thrombi are found.
(*h*) Avco Everett Research Laboratory, Inc., *Research Rept. 401*, Aug. 1974.

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BATTELLE MEMORIAL INSTITUTE, Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201. John M. Batch, Director.

011-07969-630-27

HIGH-PERFORMANCE VANE PUMP FOR AIRCRAFT HYDRAULIC SYSTEMS

(*b*) U.S. Air Force, Aero Propulsion Laboratory.
(*c*) D. L. Thomas, Research Engineer.
(*d*) Applied research and development.
(*e*) Demonstrate a variable-displacement two-lobed pressure-compensated hydraulic vane pump capable of operating at 30,000 rpm, 4000 psi, 45 gpm with MIL-H-5606B hydraulic fluid with a design life of over 1000 hours. The pump incorporates two unique concepts: (1) a pivoting-tip vane which provides full hydrodynamic lubrication between the rotating vanes and the stationary cam ring, and (2) a deformable cam ring in which displacement change is achieved by elastically deflecting the member to alter the cam-surface profile.
(*g*) The pump was satisfactorily operated at 30,000 rpm and to 3,500 psi; demonstrating that a problem with resonant vibration of the deformable cam ring was greatly improved. Following a failure at 4000 psi the pump is being rebuilt to demonstrate life and pressure-compensated operation.

—

BATTELLE MEMORIAL INSTITUTE, Pacific Northwest Laboratories, Water and Land Resources Department, Richland, Wash. 99352. D. E. Olesen, Department Manager.

012-08789-860-36

DEVELOPMENT OF A RIVER BASIN WATER QUALITY MODEL AND VERIFICATION ON THE WILLAMETTE RIVER BASIN

(*b*) U. S. Environmental Protection Agency.
(*c*) Robert G. Baca, Research Engineer.
(*d*) Development.
(*e*) A comprehensive water quality model, EXPLORE-I, was developed for use in river basin planning and water resource studies. This generalized computer model can simulate the hydrodynamics and water quality dynamics in rivers, well-mixed estuaries and stratified impoundments. The model has been set up, calibrated and verified on the Willamette River Basin in Oregon. The model formulation considers the following parameters: BOD; total organic carbon; phosphorus; nitrogen; toxic compounds; phytoplankton; zooplankton; and dissolved oxygen. The model is applicable to any river basin with widely varying hydraulic regimes.
(*f*) Completed.
(*g*) The modeling of the Willamette River and its major tributaries demonstrated the general capability of the EXPLORE-I model. Excellent agreement was obtained between predicted and observed data including flow, stage and river velocity. Good agreement was obtained for DO, BOD, inorganic nitrogen and phosphorus. Modeling of Detroit Reservoir was unsuccessful because the EPA multisegment model became inoperable.
(*h*) **Explore I: A River Basin Water Quality Model,** R. G. Baca, W. W. Waddel, C. R. Cole, A. Brandstetter, D. B. Cearlock, Battelle-Northwest, Richland, Wash., Aug. 1973.
A Dynamic Hydraulic and Water Quality Model for River Basins, W. W. Waddel, R. G. Baca, C. R. Cole, A. Brandstetter. Presented *Natl. Water Res. Engrg. Mtg., ASCE*, Wash., D. C., Jan. 1973.

012-08790-860-36

DEVELOP AND APPLY A WATER QUALITY MODEL FOR AMERICAN FALLS RESERVOIR

(*b*) U. S. Environmental Protection Agency.
(*c*) Robert G. Baca, Research Engineer.
(*d*) Development.
(*e*) Develop a generalized water quality model for eutrophic lakes and reservoirs and to demonstrate its capability with data for American Falls Reservoir in Idaho. The computer models developed in this project provide a detailed portrayal of the dynamic processes which determine the trophic states in lakes and reservoirs. The models are formulated in terms of several key environmental parameters'dissolved oxygen, biochemical oxygen demand, coliform bacteria, toxic material, algal populations and nutrient materials, and consider the major controlling factors'light, temperature, steam flows, and loading rates.
(*f*) Complete.
(*g*) Objectives were achieved within the development and demonstration of the Battelle multisegment deep reservoir models. Both the hydrothermal and water quality modules were shown to be completely operational and ready for general use in water resource studies. Application of the models to American Falls Reservoir yield these major conclusions: 1) the multisegment hydrothermal model can accurately predict temperature patterns through space and time. Accurate simulations can be obtained with little or no subjective effort, 2) the multisegment water quality model can accurately predict the DO-BOD dynamics, and 3) the water model can realistically simulate the natural patterns of algal growth and death and nutrient cycling.
(*h*) **A Generalized Water Quality Model for Eutrophic Lakes and Reservoirs,** R. G. Baca, M. W. Lorenzen, R. D. Mudd. L. V. Kimmel, Battelle-Northwest, Richland, Wash., Nov. 1974.

012-08791-860-00

A TRANSPORT MODEL FOR NITROGEN SUPERSATURATED WATERS

(*b*) Battelle-Northwest (In-house R&D).
(*c*) Robert G. Baca, Research Engineer.
(*d*) Applied research.
(*e*) The principal objectives were two-fold. The first objective was to develop a preliminary model capable of predicting the nitrogen gas regime in river-run reservoirs. The mathematical model would be able to predict the nitrogen gas concentration under a variety of different conditions as a function of flow rate, temperature and river channel geometry. The final model would also be capable of providing time-dependent or steady state predictions over any river reach of interest. The second objective of the project was to verify the model with field data for the Kootenai River from Libby Dam, Montana to Leonia, Idaho.
(*f*) Completed.
(*g*) Objectives were achieved with the formulation, development and application of a one-dimensional transport model. The differential equation was implemented in a generalized computer program. Close agreement between observed and predicted nitrogen levels in the Kootenai River support the general conclusion that the proposed dissolved nitrogen model is capable of providing reliable predictions. Accurate predictions of nitrogen supersaturation predictions can be obtained using hydrologic data generally available and at minimal computer cost.

012-08792-860-00

DEVELOPMENT OF A METHODOLOGY FOR EUTROPHICATION ASSESSMENT IN LAKES AND IMPOUNDMENTS

(*b*) U. S. Environmental Protection Agency.
(*c*) Robert G. Baca, Research Engineer.
(*d*) Development.
(*e*) To develop a generalized water quality model for eutrophic lakes and impoundments; to demonstrate the model's adequacy on Lakes Washington, Mendota and Wingra; develop a simplified methodology to predict the future trophic state of lakes based on the use of near and far term models; to develop land use-loading rate correlations; and provide an assessment manual documenting the evaluation methodology and water quality models.
(*g*) Preliminary results on temperature predictions show excellent agreement with observed data for all three lakes.

012-08793-860-52

COLUMBIA RIVER WATER QUALITY MODELING

(*b*) Atomic Energy Commission.
(*c*) Robert G. Baca.
(*d*) Development.
(*e*) Development of a mathematical model of suspended sediment transport. The final model should be capable of describing the motion, dispersal and distribution of sediments in fresh water systems. The conceptual framework of the model should include convection, diffusion, bed erosion, deposition and bed consolidation.
(*g*) A one-dimensional sediment transport model was formulated and implemented in the initial phase of study. The computer model is capable of simulating the principal components of the sedimentation cycle: bed erosion, transport in suspension, deposition and bed consolidation. An accurate and efficient numerical method based on the Galerkin finite-element technique was developed for the general solution of the model equations. The final computer model was set up on a portion of the Columbia River and functionally tested with actual flow and geometry data. In the next phase of research, these developed concepts will be conducted using laboratory data obtained from flume experiments.

012-08794-860-36

DEVELOPMENT OF A MATHEMATICAL WATER QUALITY MODEL FOR GRAYS HARBOR AND THE CHEHALIS RIVER, WASHINGTON

(*b*) U. S. Environmental Protection Agency.
(*c*) D. B. Cearlock, Manager, Environmental Management Section.
(*d*) Experimental investigation; applied research.
(*e*) This report documents the application of a mathematical hydrodynamic and water quality model to Grays Harbor and the Chehalis River, Washington. The model was successfully calibrated and verified for dissolved oxygen in 1970, 1971 and 1972. Waste discharge and water quality data were obtained from extensive surveys supervised by the Washington State Department of Ecology. The sensitivity of the model predictions to the following parameters was investigated: simulation time, reaeration rate, seaward boundary conditions, BOD exertion rate, benthic oxygen demand, discharge location, tidal exchange coefficient, and streamflow. The report has four volumes: documentation report, sensitivity analysis, system layout and data analysis, and user's manual.
(*f*) Completed.
(*g*) The results show that simulation time, benthic oxygen demand, seaward boundary conditions and waste source locations can have significant effects on model predictions.
(*h*) **Development of a Mathematical Water Quality Model for Grays Harbor and the Chehalis River, Washington,** *Rept. No. 211B01360 to U. S. Environ. Protection Agency* by Battelle-Northwest, Richland, Wash., Oct. 1974, (4 volumes).

012-08795-860-36

A WATER QUALITY MODEL FOR THE SOUTH PLATTE RIVER BASIN

(*b*) U. S. Environmental Protection Agency.
(*c*) D. B. Cearlock, Manager, Environmental Management Section.
(*d*) Experimental investigation; applied research.
(*e*) This report documents PIONEER-I, a digital computer code developed by Battelle-Northwest for application to the South Platte River Basin. The model is intended for use as a planning tool, not a detailed scientific investigation. The following water quality parameters are considered: total nitrogen, total dissolved solids, zinc, DO, carbonaceous BOD, fecal coliforms, phosphorus, ammonia, nitrite, nitrate, chlorophyll *a*, and general N^{th} order decay.
(*f*) Completed.
(*g*) The overall solution technique utilized by PIONEER-I, the individual quality models used and the application and operation of the code are described, as well as the calibration and verification studies, including a discussion of the time regimes and methods used in calibration and verification of the model, the sources of data and the problems encountered. Appendices A and B present detailed input instructions, an annotated small test problem, program and subroutine flow diagrams, a program listing and variable descriptions.
(*h*) **A Water Quality Model for the South Platte River Basin,** W. W. Waddel, C. R. Cole, R. G. Baca, *Rept. No. 211B01179 to the U. S. Environ. Protection Agency* by Battelle-Northwest, Richland, Wash., Apr. 1974.

012-08796-860-36

DEVELOPMENT OF A WATER QUALITY MODEL FOR THE SOUTH PLATTE RIVER BASIN - ADDENDUM: WATER QUALITY ANALYSIS IN THE SOUTH PLATTE RIVER BASIN

(*b*) U. S. Environmental Protection Agency.
(*c*) D. B. Cearlock, Manager, Environmental Management Section.
(*d*) Experimental investigation; applied research.
(*e*) The results of this research have produced several revisions to the PIONEER-I code (documented in an earlier report) for use specifically on the South Platte River system. The revised code contains Sand Creek as an added tributary to the South Platte River. In addition, the nitrogen calculations have been modified so that total nitrogen is the sum of the nitrogen species. Benthic oxygen demand calculations have also been corrected. A loop has been added to accommodate Burlington Ditch which withdraws from the South Platte and returns part of its flow to Sand Creek.
(*f*) Completed.
(*g*) Two versions of the revised code have been provided. The first contains the entire river basin and the second is abbreviated to include only the Denver Metropolitan Region.
(*h*) **Development of a Water Quality Model for the South Platte River Basin – Addendum, Water Quality Analysis in the South Platte River Basin,** M. W. Lorenzen, L. V. Kimmel, *Rept. No. 211B01615 to U. S. Environ. Protection Agency* by Battelle-Northwest, Richland, Wash., Oct. 1974.

012-08797-870-36

AN ASSESSMENT OF MATHEMATICAL MODELS FOR STORM AND COMBINED SEWER MANAGEMENT

(*b*) U. S. Environmental Protection Agency.
(*c*) D. B. Cearlock, Manager, Environmental Management Section.
(*d*) Experimental investigation; applied research.
(*e*) Eighteen mathematical models for the nonsteady simulation of urban runoff were evaluated to determine their suitability for the engineering assessment, planning, design and control of storm and combined sewerage systems. The models were evaluated on the basis of information published by the model builders and model users. Seven models were also tested by computer runs using both hypothetical and real catchment data. Most of the models evaluated include the nonsteady simulation of the rainfall-runoff process and flow routing in sewers; a few include also the simulation of waste-water quality, options for dimensioning sewerage system components, and features for realtime control of overflows during rainstorms.
(*g*) Not yet completed.

012-08798-820-73

ANTICIPATED EFFECTS OF AN UNLINED BRACKISH WATER CANAL ON A CONFINED MULTIPLE-AQUIFER SYSTEM

(*b*) Carolina Power and Light Co.
(*c*) J. R. Eliason, Manager, Resources Systems Section.
(*d*) Experimental investigation; applied research.
(*e*) To evaluate the impact of a planned cooling-water canal on a confined multiple-aquifer groundwater system, a mathematical model was used to describe steady-state responses resulting from a variety of conceivable hydrologic stresses. Numerical solutions were obtained by means of finite-difference approximations and a successive line over-relaxation solution technique. The model approximated three-dimensional saturated flow in aquifers of variable thickness by assuming two-dimensional flow in each aquifer with inter-aquifer transfer throughout the groundwater system.
(*f*) Completed.
(*g*) Simulation results indicated that salt-water from the estuary will eventually intrude upon municipal wells regardless of the presence of the proposed canal. The canal system will not significantly decrease the time required for estuarine saltwater contamination of the wells.
(*h*) **Anticipated Effects of an Unlined Brackish-Water Canal on a Confined Multiple-Aquifer System,** D. L. Schreiber, A. E. Reisenauer, K. L. Kipp, R. T. Jaske, *BNWL-1800*, Battelle-Northwest, Richland, Wash., Sept. 1973.

012-08799-170-00

HETRAN: A SUBPROGRAM PACKAGE FOR PREDICTING THE HEAT TRANSFER ACROSS THE SURFACE OF A NATURAL BODY OF WATER

(*c*) Robert G. Baca, Research Engineer.
(*d*) Experimental investigation; applied research.

(*e*) A computer subprogram HETRAN was developed for prediction of atmospheric heat exchange across the air-water interface of a natural water body. The program uses standard meteorologic data and analytic-empirical relationships to calculate the component energy fluxes. Included in the general heat budget are net shortwave radiation, net atmospheric radiation, back radiation, evaporative heat loss, and convective loss or gain at the air-water interface. The program is capable of predicting diurnal patterns and long-term temperature variations. The subprograms are designed so that they may be easily coupled to generalized programs for far field temperature predictions.

(*f*) Completed.

(*h*) **HETRAN: A Subprogram Package for Predicting the Heat Transfer Across the Surface of a Natural Body of Water,** D. G. Daniels, C. A. Oster, Battelle-Northwest, Richland, Wash., June 1974.

012-08800-820-52

MOVEMENT OF RADIONUCLIDES THROUGH SOILS

(*b*) Energy Research and Development Administration (Atlantic Richfield Hanford Company).

(*c*) J. R. Eliason, Manager, Resources Systems Section.

(*d*) Experimental and field investigation; applied research.

(*e*) Develop accurate and applicable transport models for describing the movement of radionuclides (and other pollutants) in complex saturated groundwater systems. Both soil chemistry (not discussed here) and hydrology research are included in the program. The latter includes the formulation of algorithms and computer programs for numerical solution of system transmissibility distribution using groundwater potentials and pump test data, and numerical solution to transient behavior of a groundwater system in response to known stresses. The programs are to be capable of analyzing both transient and steady state groundwater systems in significant detail.

(*g*) Algorithms and computer routines have been developed and applied for solving variable aquifer thickness, transient flow problems (VTT model) and for partially saturated, transient flow problems (PST model). Graphical display system is utilizing a CRT memory scope in conjunction with the digital computer and provides visual presentation of results.

(*h*) **Numerical Solution of Richard's Equation and Application to Unsaturated Flow Problems,** A. E. Reisenauer, D. B. Cearlock, C. A. Bryan, *EOS, Trans. Amer. Geophys. Union* **54,** 11, 1973.

A Study of Soil Water Potential and Temperature in Hanford Soils, J. J. C. Hsieh, A. E. Reisenauer, L. E. Brownell, Battelle-Northwest, Richland, Wash., *BNWL-1712*, 1972.

Collection and Analysis of Pump Test Data for Transmissivity Values, K. L. Kipp, R. D. Mudd, Battelle-Northwest, Richland, Wash., *BNWL-1709*, 1972.

One-Dimensional Model of the Movement of Trace Radioactive Solute Through Soil Columns: The Percol Model, R. C. Routson, R. J. Serne, Battelle-Northwest, Richland, Wash, *BNWL-1718*, 1972.

Soil Hydraulic Conductivity Calculation from Soil-Water Retention Relationships, A. E. Reisenauer, Battelle-Northwest, Richland, Wash., *BNWL-1710*, 1973.

Experimental Support Studies for the Percol and Transport Models, R. C. Routson, R. J. Serne, Battelle-Northwest, Richland, Wash., *BNWL-1719*, 1972.

Lysimeter Experiment Description and Progress Report on Neutron Measurements, J. J. C. Hsieh, L. E. Brownell, A. E. Reisenauer, Battelle-Northwest, Richland, Wash., *BNWL-1711*, 1972.

BELL AEROSPACE DIVISION OF TEXTRON, Propulsion Systems and Components, Box 1, Buffalo, N. Y. 14240.

013-08658-020-26

HIGH-SPEED TURBULENT MIXING AND COMBUSTION

(*b*) Air Force Office of Scientific Research.

(*c*) G. Rudinger, Principal Scientist.

(*d*) Analytical and experimental applied research.

(*e*) Several fluid-dynamical aspects of injection of gases and solid particles into a gas flow were studied as related to fuel injection into combustion chambers and other applications.

(*f*) Completed.

(*g*) Light and heavy gases were injected through a long transversal slot, and their penetration determined by Schlieren photography; a correlation was obtained for the penetration in terms of velocities, densities, slot width and distance from the injection point. A convenient analytical solution was derived for the penetration of single particles injected laterally into a constant flow; considerable reduction of penetration may be caused by the cross flow as a result of the nonlinearity of the equation of motion outside the Stokes drag regime. The burning rate of fuel particles may be limited by the rate at which gaseous reactants can diffuse to the surface of the particle; the benefits that might be obtained by slip between the gas and the particles were analyzed for several slip-producing flows and were found to be small for particles smaller than several tens micrometers. Fuel injection into a combustion chamber counter to the direction of the main flow allows increased time for combustion; the resultant penalties associated with the negative thrust of the fuel jet and the increased mixing loss were assessed for applications typical of ramjets, scramjets and stationary power plants.

(*h*) **Experimental Investigation of Gas Injection Through a Transverse Slot Into a Subsonic Cross Flow,** G. Rudinger, *AIAA J.* **12,** 4, pp. 566-568, Apr. 1974.

Penetration of Particles Injected into a Constant Cross Flow, G. Rudinger, *AIAA J.* **12,** 8, pp. 1138-1140, Aug. 1974.

Effect of Velocity Slip on the Burning Rate of Fuel Particles, G. Rudinger, *Symp. on the Fluid Mechanics of Combustion*, *ASME*, 1974, pp. 35-46, presented Joint Fluids Engrg. and Canadian Soc. Mech. Engrg. Conf., Montreal, May 1974.

Simultaneous Heat, Mass and Momentum Addition to a Gas Flow in a Pipe, G. Rudinger, *Joint Fluids Engrg. and Canadian Soc. Mech. Engrg. Conf.*, Montreal, May 1974, *ASME Paper No. 74-FE-14*.

013-08659-050-20

NONTANGENTIAL INJECTION OF SINGLE AND TWO-PHASE JETS INTO SUBSONIC FLOW

(*b*) Office of Naval Research (Project SQUID).

(*c*) G. Rudinger, Principal Scientist.

(*d*) Applied experimental and analytical research.

(*e*) Lateral injection of gas-particle jets into a cross flow and comparison of penetration with that of gas jets.

(*g*) It was shown that the condition for equivalence of gas-particle jets and gas jets – equal average density, flow rate, and momentum flux – are approximately satisfied if the particle velocity is at least 40 percent of the gas velocity. Particle injection velocities were measured with a laser-Doppler system, and jet trajectories were obtained photographically. Results so far indicate that 33 μm particles separate from the carrier gas. The relationship between vortex structure and stiffness of gas jets in a cross flow will be investigated by the laser-Doppler technique.

013-08660-130-26

WAVE PROPAGATION IN SUSPENSIONS OF SOLID PARTICLES IN GAS FLOW

(*b*) Air Force Office of Scientific Research (partial support).

(*c*) G. Rudinger, Principal Scientist.

(*d*) Literature review.

(*e*) Paper prepared at the request of Applied Mechanics Reviews. Waves considered were normal or oblique shock waves, sound waves, and large-amplitude waves of arbitrary wave form and pressure change.
(*f*) Completed.
(*h*) **Wave Propagation in Suspensions of Solid Particles in Gas Flow,** G. Rudinger, *Appl. Mech. Rev.* **26,** 3, pp. 273-279, Mar. 1973.

013-08661-130-26

FUNDAMENTALS AND APPLICATIONS OF GAS-PARTICLE FLOW

(*b*) Office of Naval Research (Project SQUID) and Air Force Office of Scientific Research (partial support).
(*c*) G. Rudinger, Principal Scientist.
(*d*) Literature review.
(*e*) Review of status of field in the United States, prepared at the request of AGARD.
(*f*) Completed.
(*g*) Paper presented at the meeting of the AGARD Fluid Dynamics Panel, Rome, Sept. 1974 (to be published).

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BROWN UNIVERSITY, Division of Applied Mathematics, Providence, R. I. 02912, Professor J. K. Hale, Division Chairman.

014-08665-130-54

BUBBLE DYNAMICS

(*b*) National Science Foundation.
(*c*) Professor D. Y. Hsieh.
(*d*) Theoretical; basic research for Ph.D. thesis.
(*e*) Various aspects of the dynamics of gas or vapor bubbles in liquids are studied.
(*h*) **Variational Methods and Dynamics of Nonspherical Bubbles and Liquid Drops,** D. Y. Hsieh, in *Finite Amplitude Wave Effects in Fluids* edited by L. Bjørnø, IPC Science and Tech. Press, Surrey England, pp. 220-226, 1974.
On Thresholds for Surface Waves and Subharmonics of An Oscillating Bubble, D. Y. Hsieh, *J. Acoust. Soc. Am.* **56,** 392, 1974.
Lagrangian Formulation of Bubble Dynamics, D. Y. Hsieh, to appear in *Quart. Appl. Math.*
Some Aspects on Dynamics of Nonspherical Bubbles and Liquid Drops, *Proc. Intl. Colloq. on Drops and Bubbles.* In press.
Variational Methods and Nonlinear Oscillation of Bubbles, D. Y. Hsieh, *Div. Appl. Math. Rept.*, Brown Univ., 1974.
Effects of Evaporation and Diffusion on An Oscillating Bubble, T. Wang, *Phys. of Fluids* **17,** 1121-1126, 1974.
Rectified Heat Transfer, T. Wang, *J. Acoust. Soc. Am.* **56,** 1131-1143, 1974.

014-08666-420-54

NONLINEAR WAVES AND OSCILLATIONS

(*b*) National Science Foundation.
(*c*) Professor D. Y. Hsieh.
(*d*) Theoretical and basic research for Ph.D. thesis.
(*e*) A variational method is developed to deal with the general problem of nonlinear oscillation and waves. The wave equations that have been treated include the Korteweg-DeVries equation of the water wave problem.
(*h*) **Variational Method and Nonlinear Forced Oscillations,** D. Y. Hsieh. To appear in *J. Math. Phys.*
Variational Method and Nonlinear Oscillations and Waves, D. Y. Hsieh. To appear in *J. Math. Phys.*

014-08667-060-54

DYNAMICS OF STRATIFIED FLUIDS

(*b*) National Science Foundation.
(*c*) Professor C. H. Su.
(*d*) Analytical and numerical studies.
(*e*) Investigation of the nonlinear effects of acoustic and internal gravity waves; studies of the steady flow of a stratified fluid over mountains; derivation of hydraulic jump conditions in a stratified fluid.
(*h*) **Weakly Nonlinear Acoustic Gravity Waves in the Atmosphere,** *Ph.D. Thesis*, G. F. Koehler.
Report issued by the National Center for Atmospheric Research, Boulder, Colo., containing the following articles available for distribution:
Weakling Non-linear Internal Gravity Waves in a Nearly Critical Flow, P. G. Drazin, J. D. Lee, C. H. Su.
A Note on Longwave Theory of Airflow over a Mountain, P. G. Drazin, C. H. Su.
Some Dissipative Effects on Stratified Shear Flows over an Obstacle, C. H. Su.
Continuous Flows of a Stratified Fluid over an Obstacle, J. D. Lee, C. H. Su.
Hydraulic Jumps in an Incompressible Stratified Fluid, C. H. Su.

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BROWN UNIVERSITY, Division of Engineering, Providence, R. I. 02912. Professor Roger I. Tanner.

015-08662-740-00

FINITE ELEMENT COMPUTATIONS IN FREE-SURFACE FLUID MECHANICS

(*d*) Computational project; basic research.
(*e*) Many problems in viscous jet flows and polymer extrusion problems involve the transition from fixed to free surface boundary conditions. These flows are not amenable to exact solutions and therefore a finite-element program has been written.
(*g*) Computed results for the expansion of Newtonian jets at low Reynolds numbers show good agreement with experimental results. Extension of the computations to certain non-Newtonian fluids has also been successful.
(*h*) **The Solution of Viscous Incompressible Jet and Free Surface Flows Using Finite Element Methods,** R. E. Nickell, et al., *J. Fl. Mech.* **65,** 189-206, 1974.

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CALIFORNIA INSTITUTE OF TECHNOLOGY, Department of Chemical Engineering, Pasadena, Calif. 91125. Dr. John H. Seinfeld, Professor and Chairman.

016-08702-120-54

THE MOTION OF BUBBLES, DROPS AND RIGID PARTICLES IN NEWTONIAN AND NON-NEWTONIAN FLUIDS

(*b*) Sponsored in part by the National Science Foundation.
(*c*) Professor L. G. Leal.
(*d*) Experimental and theoretical; basic research; M.S. and Ph.D. theses.
(*e*) Experimental and theoretical studies aimed at improved understanding of the motion of bubbles, drops or small particles in the slow flow regime for both Newtonian and non-Newtonian (primarily polymeric solutions) fluids.
(*h*) **On the Motion of Gas Bubbles in a Viscoelastic Liquid,** L. G. Leal, J. Skoog, A. Acrivos, *Canadian J. Chem. Engrg.* **49,** pp. 569-575, 1971.
The Slow Motion of Slender Rod-like Particles in a Second Order Fluid, L. G. Leal, accepted by *J. Fluid Mechanics.*
Inertial Migration of Rigid Spheres in Two-Dimensional Shear Flows, B. P. Ho, L. G. Leal, *J. Fluid Mech.* **65,** 365, 1974.
Dissolution of a Stationary Gas Bubble in a Viscoelastic Fluid, E. Zana, L. G. Leal, accepted by *I&EC Fundamentals.*
The Creeping Motion of Liquid Drops Through a Circular Tube of Comparable Diameter, B. P. Ho, L. G. Leal, submitted to *J. Fluid Mechanics.*

Migration of Rigid Spheres in a Two-Dimensional Unidirectional Shear Flow of a Second-Order Fluid, B. P. Ho, L. G. Leal, submitted to *J. of Fluid Mechanics*.
A Note on Lateral Migration Phenomena in a Screw Extruder, B. P. Ho, L. G. Leal, submitted to *Trans. Soc. Rheology*.
A Note on the Creeping Motion of a Viscoelastic Fluid Past a Sphere, E. Zana, G. Tiefenbruck, L. G. Leal, submitted to *J. of Fluid Mechanics*.
A Review of the Dynamics of Bubbles and Drops in a Viscoelastic Fluid, E. Zana, L. G. Leal, *Proc. 1st. Intl. Colloquium on Bubbles and Drops*, 1974.

016-08703-120-54

SUSPENSION MECHANICS AND RHEOLOGY

(*b*) Sponsored, in part, by the National Science Foundation, Petroleum Research Fund, Research Corporation, Union Carbide Corporation.
(*c*) Professor L. G. Leal.
(*d*) Primarily theoretical; basic research; Ph.D. theses.
(*e*) Theoretical studies aimed at predicting the rheological and bulk transport properties of suspensions.
(*h*) **On the Effect of Particle Couples on the Motion of a Dilute Suspension of Spheroids,** L. G. Leal, *J. Fluid Mech.* **46**, 395, 1971.
The Effect of Weak Brownian Rotations on (Spheroidal) Particles in Shear Flow, L. G. Leal, E. J. Hinch, *J. of Fluid Mech.* **46**, 685, 1971.
The Effect of Brownian Motion on the Rheological Properties of a Suspension of Non-Spherical Particles, E. J. Hinch, L. G. Leal, *J. of Fluid Mech.* **52**, 683, 1972.
A Note on Streaming Double Refraction in a Dilute Suspension of Rigid Spheroids Subject to Weak Brownian Rotations, L. G. Leal, E. J. Hinch, *Rheologica Acta* **11**, 190, 1972.
On the Effective Conductivity of a Dilute Suspension of Spherical Drops in the Limit of Low Particle Peclet Number, L. G. Leal, *Chem. Engrg. Comm.* **1**, 1973.
The Rheology of a Suspension of Nearly Spherical Particles Subject to Brownian Rotations, L. G. Leal, E. J. Hinch, *J. of Fluid Mech.* **55**, 745, 1972.
Note on the Rheology of a Dilute Suspension of Dipolar Spheres with Weak Brownian Couples, L. G. Leal, E. J. Hinch, *J. of Fluid Mech.* **56**, 803, 1972.
Time-Dependent Shear Flows of a Suspension of Particles with Weak Brownian Rotations, E. J. Hinch, L. G. Leal, *J. of Fluid Mech.* **57**, 753, 1973.
Theoretical Studies of a Suspension of Rigid Particles Affected by Brownian Couples, L. G. Leal, E. J. Hinch, *Proc. 6th Intl. Congress of Rheologica Acta* **12**, 127, 1973.
Constitutive Equations in Suspension Mechanics, Part I, General Formulation, E. J. Hinch, L. G. Leal, submitted to *J. of Fluid Mechanics*.

016-08704-060-54

GEOPHYSICAL FLUID DYNAMICS: BUOYANCY DRIVEN FLOWS, TURBULENT MODEL DEVELOPMENT

(*b*) Sponsored, in part, by the National Science Foundation.
(*c*) Professor L. G. Leal.
(*d*) Theoretical; basic research; Ph.D. theses.
(*e*) Theoretical studies aimed at problems which involve both ambient stratification and "local" buoyancy induced convection. Theory for mean gravitational circulation in shallow bodies of water. Development of a computationally useful model for calculation of turbulent motions with stratification in mescoscale (or smaller) regions.
(*h*) **Combined Forced and Free Convection Heat Transfer from a Horizontal Flat Plate,** L. G. Leal, *J. Appl. Math. and Phys.* (*ZAMP*) **24**, 1973.
Combined Forced and Free Convection Flow Past a Horizontal Flat Plate, G. E. Robertson, J. H. Seinfeld, L. G. Leal, *AIChE J.* **19**, 998, 1973.
Natural Convection Flow in an Enclosed Cavity of Small Aspect Ratio with Differentially Heated Side Walls: Part I Asymptotic Theory, D. E. Cormack, L. G. Leal, J. Imberger, *J. of Fluid Mech.* **65**, 209, 1974.
Natural Convection Flow in an Enclosed Cavity of Small Aspect Ratio with Differentially Heated Side Walls: Part II. Numerical Solutions, D. E. Cormack, L. G. Leal, J. H. Seinfeld, *J. of Fluid Mech.* **65**, 231, 1974.
Comments on **High Rayleigh Number Convection in an Enclosure – A Numerical Study,** D. E. Cormack, L. G. Leal, *Physics of Fluids* **17**, 1049, 1974.
The Role of Upper Surface Conditions in Establishing the Flow Structure for Natural Convection in a Shallow Cavity with Differentially Heated End Walls, G. P. Stone, D. E. Cormack, L. G. Leal, accepted by *Intl. J. Heat and Mass Transfer*.
Wakes in Stratified Flow Past a Hot or Cold Two-Dimensional Body, G. E. Robertson, J. H. Seinfeld, L. G. Leal, submitted to *J. of Fluid Mechanics*.
Studies of a Phenomenological Turbulence Model, D. E. Cormack, L. G. Leal, J. H. Seinfeld, *CIT Report*.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Division of Engineering and Applied Science, Engineering Science Department, Pasadena, Calif. 91125. Dr. Robert H. Cannon, Jr., Division Chairman.

017-01548-230-20

PROBLEMS IN HYDRODYNAMICS

(*b*) Office of Naval Research, Department of the Navy.
(*c*) Professor Milton S. Plesset.
(*d*) Theoretical and experimental; basic research.
(*e*) Studies of cavitating and noncavitating flow; dynamic behavior of cavitation bubbles; theoretical studies of cavitation damage.
(*h*) **Cavitation and Cavitation Damage,** M. S. Plesset, *Rept. No. 85-58*, Mar. 1973.
Nonlinear Oscillations of a Gas Bubble in a Viscous Incompressible Liquid, M. S. Plesset, A. Prosperetti, *Rept. No. 85-61*, May 1973.
Nonlinear Oscillations of Gas Bubbles in Liquids. Transient Solutions and the Connection Between Cavitation and Subharmonic Emission, A. Prosperetti, *J. Acous. Soc. of Amer.*, Jan. 1976.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Graduate Aeronautical Laboratories, Pasadena, Calif. 91109. Dr. Hans W. Liepmann, Laboratory Director.

018-09370-030-26

LASER VELOCIMETER MEASUREMENTS IN TRAILING VORTEX WAKES

(*b*) Air Force Office of Scientific Research; The Ford Foundation.
(*c*) Dr. Steven J. Barker.
(*e*) A program of velocity measurements in trailing vortex wakes using a laser-Doppler velocimeter was begun last year and is expected to continue. The laser-Doppler technique is the only practical way to measure velocities in vortex wakes generated in the laboratory because of the sensitivity of these flows to probe interference effects. The measurements made to date have been conducted in the GALCIT Free Surface Water Tunnel, using a lifting hydrofoil model at the upstream end of the test section to generate the vortex wake. Further measurements will be conducted in a new low-speed water channel presently under construction.
(*g*) The results obtained so far include profiles of the axial and tangential velocity components in trailing vortices behind

hydrofoils of various planform shape. The data appear to be in reasonable agreement with the laminar trailing vortex theory developed by Moore and Saffman. Further studies will include tests of different planforms at larger distances downstream from the model. In addition, the vortex roll-up process behind a ring wing at an angle of attack will be studied in detail. Numerical computations are also being done for the ring wing case.

(*h*) **Laser Anemometer Measurements of Trailing Vortices in Water,** G. R. Baker, S. J. Barker, K. K. Bofah, P. G. Saffman, *J. Fluid Mechanics* **65**, 2, 1974.
Laser-Doppler Measurements of Trailing Vortices in a Water Tunnel, S. J. Barker, *Proc. ONR 10th Symp. Naval Hydrodynamics*, 1974.

018-09371-160-20

MEASUREMENTS OF RADIATED NOISE IN A HIGH-SPEED WATER TUNNEL

(*b*) Office of Naval Research.
(*c*) Dr. Steven J. Barker.
(*e*) Measurements of hydrodynamic radiated noise in Caltech's High-Speed Water Tunnel have produced some very encouraging results in the past year. The object of the program has been to measure the sound radiated from both cavitating and non-cavitating turbulent boundary layers in water, and to establish the feasibility of making such measurements in a water tunnel facility. Measurements of the noise spectrum in the clear tunnel configuration (no model in the test section) have shown that, in the lower frequency end of the spectrum, the wall pressure fluctuations of the test section wall boundary layer are the dominant source. At higher frequencies, however, radiated noise from the very thin boundary layer on a model mounted in the test section dominates the background noise from the tunnel walls.
(*g*) The dependence of the intensity of non-cavitating boundary layer noise upon flow velocity has been measured over a wide range of velocities and model configurations. It has been found that the noise spectrum level varies with velocity as U^5 at lower frequencies, as U^6 at intermediate frequencies, and as U^8 at the highest frequencies at which the noise can be measured. The classical quadrupole radiation theory of Lighthill predicts a U^8 behavior, so that the quadrupole representation of boundary layer noise sources does not appear to be valid over the entire frequency spectrum. The second part of this program has been the measurement of cavitation-produced radiated noise from various hydrofoil models. It has been shown that a significant part of the cavitation noise can be produced by vibrations of the model itself, driven by the collapse of the vapor cavity on its surface. Noise from trailing vortex cavities and supercavitating models has also been measured.
(*h*) **Measurements of Radiated Noise from Cavitating Hydrofoils,** S. J. Barker, *Proc. 1973 ASME Polyphase Flow Forum.*

018-09372-040-14

PERIODIC CAVITY OSCILLATIONS

(*b*) Department of the Army (Army Research Office); Department of Defense (Advanced Research Projects Agency) (through U. S. Army Research Office).
(*c*) Professor Wilhelm Behrens.
(*e*) A fluid flow passing over a rectangular cavity may induce large periodic oscillations inside the cavity. Experiments are being carried out at low subsonic speeds using axisymmetric models in order to identify the mechanisms responsible for sustained oscillations. The shear layer separating the flow in the cavity and the external flow is dynamically unstable, and infinitesimal disturbances in a certain frequency band are amplified in the shear layer. The fluctuations in the shear layer create intense pressure fluctuations near the downstream edge of the cavity and cause additional flowfluctuation in and around the cavity. When this feedback is positive, there will be a sustained flow oscillation in the cavity. Parameters governing this feedback mechanism are being studied in this investigation.

018-09373-540-50

EXPERIMENTAL STUDY OF FLOW ABOUT A STALLED TWO-DIMENSIONAL AIRFOIL

(*b*) National Aeronautics and Space Administration (Ames Research Center).
(*c*) Professor Donald E. Coles.
(*e*) To document experimentally the mean flow, including the turbulent Reynolds stresses, for a two-dimensional airfoil in the stalled regime near maximum lift.
The main instrumentation is a flying hot wire which is traversed through the flow on the end of a rotating arm at speeds sufficient to make the relative velocity always positive. Data are obtained by repeated digital sampling at points spaced about 2 cm apart along the wire trajectory. A computer-controlled data acquisition system (computer, disc, magnetic tape, plotter, A-D converter, teletype) is used on line to record and edit data from the hot wires and from other instrumentation. The flying hot-wire apparatus has been tested in the empty test section of the GALCIT 10-foot wind tunnel at tunnel speeds up to 50 m/sec (relative speeds at the hot wire up to 80 m/sec) without serious difficulties. The associated computer program has been thoroughly tested and is working well. The flying-hot-wire technique is fast and powerful, and the feature of self-calibration of X-wire arrays is particularly useful.
An airfoil model (NACA 4412 section) has been fabricated of glass-reinforced polyester resin. The model has a span of two meters and a chord of about 0.9 meters. Work is proceeding on instrumentation of this model and on construction of a supporting structure for mounting the model in the wind tunnel.

018-09374-010-00

TURBULENT BOUNDARY LAYER OVER A WAVY WALL

(*c*) Professor Toshi Kubota.
(*e*) In the turbulent boundary layer over a wavy wall, the intensity of mixing is affected by the pressure gradients and the streamline curvatures induced by the waviness of the wall. A turbulent field method using the turbulence energy equation similar to the scheme of Bradshaw, Ferriss, and Atwell is employed for the present problem with suitable modification to include the viscous sublayer. The governing differential equations are linearized based on the small amplitude assumption. An orthogonal curvilinear coordinate system is used to avoid the severe restriction near the wall. An analytic solution is obtained by using asymptotic matched expansions for the large Reynolds number and hence the small skin-friction coefficient.
(*g*) The analytical results show a good agreement with experimental data for the velocity profiles, but the skin friction perturbation turns out to be about 30 percent higher than the measured values. The effect of streamwise pressure gradient induced by the waviness on the turbulent shear stress distribution near the wall is being investigated.

018-09375-030-00

FLOW INDUCED BY A VEHICLE MOVING IN A TUBE

(*c*) Professor Toshi Kubota.
(*e*) When a vehicle moves in a tunnel, it acts like a leaky piston causing the air in the tunnel to move. This increases dynamic drag on the vehicle by a large factor compared to that of the vehicle moving in an open space. Hence, in designing a tunnel or subway for a mass-transit system, it is important to investigate the parameters affecting the vehicle drag and the tunnel flow velocity. The velocity and pressure in the tunnel and around the vehicle depend on the geometry of the tunnel cross section, the tunnel wall condition, the tunnel length, the tunnel vent size and location, and the tunnel exit configurations, as well as on the vehicle geometry and speed. Nonsteady motion of the air in the tunnel is analyzed for compressible turbulent flow

using an integral method. The resulting partial differential equations, with time and distance along the tunnel as independent variables, are integrated numerically for sample cases: (1) a vehicle in a straight tunnel; (2) a vehicle in a tunnel with a vent; and (3) a vehicle entering a tunnel.

(*h*) **Nonsteady Fluid Mechanics of Vehicles in Tubes,** M. Rizk, *Ph.D. Thesis*, Calif. Inst. of Tech., June 1974.

018-09376-030-14

TURBULENT FLOWS IN THE WAKE OF SELF-PROPELLED BODIES

(*b*) Department of the Army (Army Research Office); Department of Defense (Advanced Research Projects Agency); Alfred P. Sloan Foundation.
(*c*) Professor Lester Lees.
(*e*) In order to complement earlier theoretical investigation of the turbulent wake behind self-propelled bodies, an experimental program has been initiated. Measurements are being conducted in the wake of a circular pipe mounted parallel to the flowin a low-speed wind tunnel. A controlled amount of air is injected through the pipe to achieve a momentumless wake, and mean and fluctuation velocities are being measured in the wake. The effect of the ratio of the jet diameter to the boundary-layer thickness on the wake development will be investigated by artificially thickening the boundary layer on the pipe.

018-09377-030-20

INFLUENCE OF A NEARBY WALL ON FLOW PAST A CYLINDER

(*b*) Department of the Navy (Office of Naval Research).
(*c*) Professor Anatol Roshko.
(*e*) There is surprisingly little information on the effect of a nearby wall on the flow past a cylinder. The problem is of importance for wind flow over structures; for pipe lines or cables near the bottom of a river; for underwater marine structures, etc. Some measurements of pressure distributions on a circular cylinder near a wind tunnel wall gave the surprising result that lift away from the wall is developed. The same result was found for a cylinder of triangular cross section (for which the separation points are fixed). The effect of various wall distances on the pressure distribution and forces has been determined. Some further measurements are being made on two cylinders in proximity to each other.

018-09378-020-20

TURBULENT MIXING WITH DENSITY DIFFERENCE

(*b*) Department of the Navy (Office of Naval Research).
(*c*) Professor Anatol Roshko.
(*e*) Two problems are being studied: (1) Confined mixing between two streams of different velocities and different densities. This flow is interesting for the ejector problem (density difference has a strong effect on pressure rise and other ejector performance parameters) as well as for the basic turbulent mixing problem (effect of the walls on large coherent structures, etc.). (2) Wake with different densities on the two sides. The wake of a splitter plate which initially separates two different gas flows with the same velocities is being studied. The mixing region between them may be called a "wake." The effects of the density difference on the turbulent mixing, on the wake spread, on the base pressure, and on the vortex shedding are being investigated.
(*h*) **On Density Effects and Large Structure in Turbulent Mixing Layers,** G. L. Brown, A. Roshko, *J. Fluid Mechanics* **64**, p. 775, 1974.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103. Dr. W. H. Pickering, Laboratory Director.

019-07921-540-50

DYNAMICS OF JET IMPINGEMENT

(*b*) NASA-OAST (RP).
(*c*) Jack H. Rupe, Research Group Supervisor.
(*d*) Experimental investigation and analytical correlations; applied research.
(*e*) Studies of nonreactive mass and mixture ratio distributions formed by impinging liquid and gas jets have been conducted. These studies are intended to provide design criteria for the injectors of so-called bimodal rocket engines. Such engines typically utilize a gaseous fuel and a liquid oxidizer in the high thrust producing mode of a system having multi-thrust level capability.
(*f*) Completed.
(*g*) It was shown that the general characteristics of sprays produced by gas/liquid pairs were not different in any fundamental respect from those formed by liquid/liquid pairs.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Division of Engineering and Applied Science, W. M. Keck Laboratory of Hydraulics and Water Resources, Pasadena, Calif. 91125. Dr. Robert H. Cannon, Jr., Division Chairman.

021-07144-220-54

BASIC RESEARCH IN SEDIMENTATION

(*b*) National Science Foundation.
(*c*) Professors V. A. Vanoni, N. H. Brooks.
(*d*) Experimental and theoretical.
(*e*) Flume studies are made to determine the effect of water temperature on sediment transport rate, flow resistance and other characteristics of flows with sediment beds.
(*g*) The effect of water temperature on bed load transportation and concentration of suspended sediment near the bed can be expressed in terms of the boundary Reynolds number, $R = U_t d_s/\nu$ in which U_t = shear velocity, d_s = median size of bed sediment and ν = kinematic viscosity of the water. An increase in water temperature will result in an increase in sediment discharge when R is less than 10, a decrease in sediment discharge when R is greater than 10 and less than 200, and no change in sediment discharge when R exceeds 200.
(*h*) **Temperature Effects in Low-Transport Flat-Bed Flows,** B. D. Taylor, V. A. Vanoni, *J. Hydraulics Div., ASCE* **98,** HY8, Aug. 1972, pp. 1427-1445.
Temperature Effects in High-Transport Flat-Bed Flows, B. D. Taylor, V. A. Vanoni, *J. Hydraulics Div., ASCE* **98,** HY12, Dec. 1972, pp. 2191-2206.
Temperature Effects in Flows Over Nonplanar Beds, B. D. Taylor, *J. Hydraulics Div., ASCE* **100,** HY12, Dec. 1974, pp. 1785-1807.

021-07146-020-36

MIXING IN RIVERS AND ESTUARIES

(*b*) Environmental Protection Agency.
(*c*) Professor Norman H. Brooks.
(*d*) Experimental and theoretical research.
(*e*) Various flow phenomena of importance to transport and dispersion of pollutants in hydrologic and coastal environments have been studied. The results are useful in two general ways: first, to facilitate the prediction of ambient water quality from effluent characteristics in various water environments; and secondly, to provide the basis for design of systems (like outfalls) required to meet given ambient water quality requirements.
(*f*) Completed.
(*g*) The results for buoyant jets may be used for the design of waste-water outfalls in oceans, reservoirs, lakes, and large estuaries. Particular emphasis is given to line sources (or

slot jets) which represent long multiple-outlet diffusers, which are necessary for all large discharges to get high dilutions. For reservoirs which are density stratified, the results include formulations for prediction of selective withdrawal, and a simulation procedure for predicting reservoir mixing by systems which pump water from one level to the other. For application to rivers and estuaries, laboratory flume experiments were made to measure transverse mixing of buoyant or heavy tracer flows as well as for neutral-density flows.

(*h*) **Dispersion in Hydrologic and Coastal Environments,** N. H. Brooks, Final Rept. to Natl. Coastal Pollution Research Program, EPA, *W. M. Keck Lab Report No. KH-R-29*, Dec. 1972, 136 pages.

021-07147-060-36

TURBULENT JET ENTRAINMENT

(*b*) National Science Foundation.
(*c*) Associate Professor E. J. List.
(*d*) Basic; experimental and theoretical.
(*e*) The turbulent entrainment into vertical jets and plumes is being studied with a view to resolving the debate concerning entrainment coefficients for buoyant jets. Dimensional analysis is being used to predict the basic form of the entrainment function. Experimental studies of two-dimensional buoyant jets in which velocities and density anomalies are measured are used to relate the jet properties to the local jet Froude number.
(*g*) The entrainment coefficient has been found to be a function of the local jet Froude number and a jet expansion coefficient. Explicit forms have been found for the momentum flux and volume flux in turbulent buoyant jets by expanding the functional form for entrainment in terms of the inverse jet Froude number and the slowly varying expansion coefficient. Good agreement with previously published experimental results for axisymmetric buoyant jets has been found. The experimental studies of two-dimensional buoyant jets show that local turbulence properties in the jets are strongly dependent on the local Froude number. Explicit relations have been found for the growth of two-dimensional jets with buoyancy.
(*h*) **Turbulent Entrainment in Buoyant Jets and Plumes,** E. J. List, J. Imberger, *J. Hyd. Div., ASCE* 99, HY9, 1461-1474, Sept. 1973.
Closure of Discussion to Turbulent Entrainment in Buoyant Jets and Plumes, E. J. List, J. Imberger, *J. Hyd. Div., ASCE* **101**, HY5, 617-620, May 1975.

021-07923-420-54

GENERATION AND COASTAL EFFECTS OF TSUNAMIS

(*b*) National Science Foundation.
(*c*) Professor Fredric Raichlen or Dr. Joseph L. Hammack, Jr.
(*d*) Experimental and theoretical research.
(*e*) Predicting the potential tsunami hazard at a specific coastal site requires an understanding of generation of the tsunami; propagation of the tsunami across the variable depth ocean; the response characteristics of the coastal region to the incident wave system. The study underway is an effort to provide additional insight into these aspects of the tsunami problem for source mechanism with idealized tectonic features.
(*g*) Linear theory has been developed for the generation process which appears to describe adequately the initial wave system and to predict correctly the maximum height of waves which are produced for simple time-displacement histories. The laboratory program is being conducted in a wave tank where a rectangular section of the bottom can be moved in a programmed manner either upwards or downwards. It has been found that in this two-dimensional and constant depth tank, a theory which incorporates both the effects of nonlinearities and frequency dispersion is necessary to describe properly an evolving wave system. The propagation of a tsunami-like wave in a density-stratified fluid has also been investigated both experimentally and theoretically. A laser wave gage has been developed to measure the amplitude of the wave at the interface. In this case, waves are generated also by moving a section of the bottom of the wave tank and four wave systems propagate from the source: the initial primary wave in the lighter fluid with an inphase disturbance at the interface, and a slower interfacial wave with an out-of-phase wave traveling at the free surface.
(*h*) **A Note on Tsunamis – Their Generation and Propagation in an Ocean of Uniform Depth,** J. Fluid Mech. **60**, 4, Oct. 1973, pp. 769-800.
The Initial Wave of a Tsunami Near Its Source, J. L. Hammack, Jr., F. Raichlen, *Proc. 5th World Conf. on Earthquake Engrg.*, Rome, Italy, June 1973, *Paper 357e*.
The Korteweg-deVries Equation and Water Waves – II. Comparison with Experiments, J. L. Hammack, Jr., H. Segur, *J. Fluid Mech.* **65**, 2, Aug. 1974, pp. 289-314.

021-07924-430-54

THE STABILITY OF ROCK PAVEMENTS EXPOSED TO WAVES

(*b*) National Science Foundation.
(*c*) Professor Fredric Raichlen or Mr. Ehud Naheer.
(*d*) Experimental and theoretical research.
(*e*) Armor material is placed around pipelines and other structures located on the bottom which are exposed to breaking waves to prevent the undermining and subsequent failure of the structure due to waves. To design such protection adequately, it is necessary to understand the mechanics of motion of large armor material on the bottom when exposed to extreme waves.
(*g*) Initial studies have been conducted on the incipient motion of spherical particles resting on a bed of spheres when exposed to both breaking and nonbreaking solitary waves. Reasonable agreement has been obtained between theory and experiment regarding the wave height which causes incipient motion of the sphere. The important parameters which describe the incipient motion are the ratio of the incident wave height to the depth; the ratio of the diameter of the bed spheres to the depth, and the ratio of the diameter of the isolated sphere to the depth; the submerged specific weight of the spheres; and the angle of repose of the isolated sphere. In addition experimental studies are being conducted using rock as bed material; the percent of material moved by waves is found to correlate well with a theoretically determined Shield's parameter.

021-08817-870-36

AIR-WATER-LAND RELATIONSHIPS FOR SELECTED POLLUTANTS IN SOUTHERN CALIFORNIA

(*b*) Environmental Protection Agency.
(*c*) Dr. R. C. Y. Koh.
(*d*) Experimental and theoretical.
(*e*) Provide integrated regional analysis of what happens to single elements considering all possible pathways to the environment and subsequent phase changes, dispersion patterns, interchanges between air, land and water, and biological uptake. Studies of this type were initiated previously at Caltech with the support of a grant from the Rockefeller Foundation. The hydraulic aspects of the research include the analysis of dispersion and mixing phenomenon from sources of various kinds such as sewage outfalls, runoff and atmospheric fallout.
(*g*) The dispersion and fate of particulates from outfalls can be greatly different from that of the fluid phase of the discharge. It has also been found that the orientation of the ocean current, with respect to the outfall diffuser, plays a smaller role in determining the mixing than previously envisioned.

021-08818-870-54

DISPERSION OF POLLUTANTS IN WATER ENVIRONMENTS

(*b*) National Science Foundation.
(*c*) Professor Norman H. Brooks or Associate Professor E. J. List.
(*d*) Basic; experimental, theoretical.

(*e*) The vertical mixing across a horizontal density interface is being studied in a two layer flow in the laboratory. Simultaneous measurements of turbulent velocities and tracer concentrations are being used to relate the mean vertical turbulent fluxes of buoyancy to the Richardson number of the flow.

021-08819-870-00

DESIGN OF OCEAN THERMAL OUTFALL SYSTEMS

(*b*) Ford Energy Research Program at Caltech.
(*c*) Associate Professor E. J. List or Dr. R. C. Y. Koh.
(*d*) Basic and applied; experimental, theoretical.
(*e*) Rational design procedures for intakes and outfalls for ocean sited thermal power plants using once-through cooling are being developed. The emphasis is on understanding the flow dynamics of warm discharge water from the point of entry into the ocean until the discharge plume is no longer identifiable.
(*g*) Preliminary experiments and analysis have been completed in which the regions of influence of the discharge geometry, buoyancy, volume and momentum fluxes, and interfacial friction have been identified. Work is progressing on developing an understanding of the importance of interfacial heat transfer to the discharge dynamics.

021-08820-750-70

EFFECT OF DISTORTION IN HYDRAULIC MODEL TESTING OF THERMAL OUTFALL DIFFUSER

(*b*) Bechtel Corporation; National Science Foundation.
(*c*) Dr. R. C. Y. Koh.
(*d*) Basic; experimental.
(*e*) Laboratory investigations to determine the dispersion of heated effluents often require that models be distorted in order to account properly for the effect of friction. A set of experiments was conducted in a 20 × 36-foot model basin where the same discharge diffuser was modeled at several distortion ratios. Specifically, the horizontal length scales used were 800:1 and 400:1, while the vertical length ratios were 200:1 and 100:1. In this fashion, four sets of experiments, at distortion ratios of 8:1, 4:1 and 2:1 were performed.
(*g*) The results indicate that while the detailed pattern of heat distribution may be somewhat different, the overall properties (such as maximum temperature excess) remain essentially independent of the distortion or scale ratio within the range tested.
(*h*) **Hydraulic Investigations of Thermal Outfalls for the Proposed Mendocino Nuclear Power Plant,** R. C. Y. Koh, N. H. Brooks, E. J. List, *Progress Rept. No. 1 to Bechtel Corp.* (*Tech. Memo 72-1*), Oct. 31, 1972, 27 pp.; *Progress Rept. No. 2* (*Tech. Memo 73-3*), Feb. 26, 1973, 56 pp., W. M. Keck Lab.

021-08821-870-73

DESIGN CONCEPTS FOR OUTFALL DIFFUSERS FOR THERMAL DISCHARGES FROM COASTAL POWER PLANTS

(*b*) Southern California Edison Company.
(*c*) Dr. R. C. Y. Koh or Assoc. Professor E. J. List.
(*d*) Basic and applied.
(*e*) During 1973-74, hydraulic model studies (started in 1972) were conducted to develop the thermal outfalls for the San Onofre Nuclear Generating Station (Southern California Edison Company) where Units 2 and 3 (1100 megawatts (each) are being planned for installation within the next five years. Additional tests were made to determine the thermal patterns at the intake area due to reverse flow in the system for heat treatment and to measure the effect of the existing Unit 1 thermal field on the intake temperatures for all three units.
(*f*) Completed.
(*g*) For the new units the laboratory studies resulted in recommended designs to discharge the heated water through two 2500-foot long diffuser pipes, extending from 3500 to 8500 feet offshore (depths 30 to 50 feet). The pipes will each be equipped with 63 nozzles to jet the flow in the offshore direction and will thereby induce an offshore drift of warm water away from the coast. The evaluations of various alternate schemes were accomplished by hydraulic model studies based on Froude's law. Most tests were made at distortion of the length scales: 800:1 horizontal and 200:1 vertical. Temperature contour maps were made with an array of 112 thermistors, sampled by a data acquisition system leading to computer processing and mapping. In addition to assisting the power companies with their immediate design problems, these studies have defined a number of important stratified flow problems for subsequent research.
(*h*) **Hydraulic Investigations of Thermal Outfalls for the San Onofre Nuclear Power Plant,** N. H. Brooks, R. C. Y. Koh, E. J. List, *Progress Rept. No. 1 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo No. 72-2*, Dec. 8, 1972, 47 pages.
Hydraulic Investigations of Thermal Outfalls for the San Onofre Nuclear Power Plant, N. H. Brooks, R. C. Y. Koh, E. J. List, E. J. Wolanski, *Progress Rept. No. 2 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo No. 73-2*, Jan. 26, 1973, 9 pages.
Hydraulic Tests of Discharge Ports – Hydraulic Investigations of Thermal Outfalls for the San Onofre Nuclear Power Plant, R. C. Y. Koh, *Progress Rept. No. 3 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo No. 73-4*, Mar. 30, 1973, 118 pages.
Basin Model Studies of Diffusers, Hydraulic Investigations of Thermal Outfalls for the San Onofre Nuclear Power Plant, R. C. Y. Koh, N. H. Brooks, E. J. Wolanski, E. J. List, *Progress Rept. No. 4 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo No. 73-5*, May 1, 1973, 71 pages.
Large-Scale Sectional Model Tests of Diffuser Operation, Hydraulic Investigations of Thermal Outfalls for the San Onofre Nuclear Power Plant, E. J. List, *Progress Rept. No. 5 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo 73-6*, July 1973, 45 pages.
Hydraulic Tests of Thermal Dispersion for Unit 1 of the San Onofre Nuclear Power Plant, R. C. Y. Koh, *Progress Rept. No. 6 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo 73-7*, July 31, 1973, 50 pages.
Heat Treatment of Units 2 and 3 Intakes for the San Onofre Nuclear Power Plant, R. C. Y. Koh, *Progress Rept. No. 7 to Southern Calif. Edison Co., W. M. Keck Lab Tech. Memo No. 73-8*, Sept. 1, 1973, 48 pages.
Hydraulic Modeling of Thermal Outfall Diffusers for the San Onofre Nuclear Power Plant, R. C. Y. Koh, N. H. Brooks, E. J. List, E. J. Wolanski, *Final Report to Southern Calif. Edison Co., W. M. Keck Lab Report No. KH-R-30*, Jan. 1974, 168 pages.
Thermal Discharge Considerations in Power Plant Siting, E. J. List, *Proc. Thermo-Fluids Conf.*, Inst. Eng. Australia, Sydney, Australia, Dec. 1972, pp. 1-6.
Interpretations of Results from Hydraulic Modeling of Thermal Outfall Diffusers for the San Onofre Nuclear Power Plant, E. J. List, R. C. Y. Koh, *Rept. to Southern Calif. Edison Co., W. M. Keck Lab Report No. KH-R-31*, Sept. 1974, 89 pages.

021-08822-870-54

FLUID MECHANICS OF OCEAN OUTFALLS

(*b*) National Science Foundation.
(*c*) Associate Professor E. J. List or Dr. R. C. Y. Koh.
(*d*) Basic; theoretical and experimental.
(*e*) Research on the fluid mechanics of ocean outfalls for waste-water discharges was continued during the past year with the initiation of two experimental thesis studies. One concerns the behavior of a finite line plume in an ambient liquid of uniform density, limited depth and steady current. The line plume (line source of buoyancy) represents

an idealized multiple-port diffusion structure discharging sewage effluent in deep water. Experiments are being conducted in a 20 x 36-foot basin with simulated diffusers only a few feet in length in water depths of only a few tenths of a foot. The second study deals with buoyant discharge from a single round jet or slot jet into a stratified body of water in a long laboratory tank (flume with ends blocked). An ambient current is simulated by towing the jet along the flume at a constant rate. The maximum height of rise, the dilutions, and the thickness of the cloud are being measured.

(*g*) Experiments performed to date show the development of three-dimensional flow patterns is associated with diffuser structures and the assumption of a two-dimensional flow pattern is grossly inadequate because of strong end effects.

(*h*) **Fluid Mechanics of Waste Water Disposal in the Ocean,** R. C. Y. Koh, N. H. Brooks, *Annual Review of Fluid Mechanics* 7, 1975.
Hydrologic Transport of Wastes, N. H. Brooks, *Flow Studies in Air and Water Pollution, ASME,* 1973, pp. 1-7. (Joint Meeting of Fluids Engrg. and Applied Mechanics Divisions at Atlanta, June 1973.)

021-08823-220-54

DIMENSIONAL ANALYSIS OF ALLUVIAL FLOWS

(*b*) National Science Foundation.
(*c*) Professor V. A. Vanoni.
(*d*) Theoretical.
(*e*) Bed forms of laboratory and field streams with sand beds have been clearly denoted in terms of three dimensionless combinations of flow velocity and depth, median sediment size, kinematic viscosity of the water and the acceleration of gravity.
(*h*) **Factors Determining Bed Forms of Alluvial Streams,** V. A. Vanoni, *J. Hydraulics Div., ASCE* **100**, HY3, Mar. 1974, pp. 363-377.

021-08824-420-54

RUN-UP DUE TO BREAKING AND NON-BREAKING WAVES

(*b*) National Science Foundation.
(*c*) Professor Fredric Raichlen.
(*d*) Experimental investigation.
(*e*) Investigate, in a fundamental manner, run-up on rubble-mound structures in the laboratory which are exposed to non-breaking (weakly nonlinear) and breaking (strongly nonlinear) periodic waves.
(*g*) Waves are generated in a wave tank which can be tilted from horizontal to a maximum slope of one vertical to fifty horizontal. The wave machine is an integral part of the wave tank; thus, waves can be propagated in water with decreasing depth thereby producing breaking waves at a predetermined location. Two structures presently are used in this study: a smooth-face structure built at a slope of one vertical to two horizontal and a rubble-mound slope with a fitted rock-face constructed to the same slope. A miniaturized gage has been developed which allows the run-up to be recorded continuously. The relative run-up has been found to be a function of the ratio of the depth to the wave length, and the wave height to depth (or wave height to wave length). For a given depth-to-wave-length, it is found that the relative run-up increases with the ratio of wave height to depth to a maximum and then decreases. The relative run-up associated with the wave which breaks at the toe of the structure is significantly less than the relative run-up obtained from non-breaking waves.
(*h*) **Run-Up Due to Breaking and Non-Breaking Waves,** F. Raichlen, J. L. Hammack, Jr., *Proc. 14th Conf. on Coastal Engrg.,* Copenhagen, Denmark, June 1974.

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CALIFORNIA STATE UNIVERSITY, FULLERTON, School of Engineering, Fullerton, Calif. 92634. Richard R. Brock, Chairman, Civil Engineering/Engineering Mechanics Faculty.

022-07978-820-33

HYDRODYNAMICS OF ARTIFICIAL GROUNDWATER RECHARGE

(*b*) Office of Water Resources Research.
(*d*) Experimental and theoretical research, will include Ph.D. dissertation.
(*e*) A study to develop reliable methods for predicting the hydrodynamic behavior of various artificial groundwater recharge patterns in unconfined aquifers. A sand model, mathematical models and field studies are being employed.
(*g*) Range of validity of the D-F theories for predicting motion of groundwater table beneath strip and square basins was determined. Experimental results agreed with theoretical predictions.
(*h*) **Hydrodynamics of Artificial Groundwater Recharge,** A. C. Amar, *Ph.D. Dissertation,* Univ. of Calif., Irvine, Calif. 1973.
Groundwater Recharge, Strip Basin Experiments, R. R. Brock, A. C. Amar, *J. of Hydraulics Div., ASCE* **100**, HY4, Apr. 1974.
Technical Completion Report, R. R. Brock, *OWRR C-3112,* 135 p., 1974, Water Resources Sci. Info. Center, Washington, D. C.

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CALIFORNIA STATE UNIVERSITY, SACRAMENTO, Department of Civil Engineering, 6000 Jay Street, Sacramento, Calif. 95819. Norman J. Castellan, Department Chairman.

023-07625-220-80

RELATIONSHIPS OF SEDIMENT TRANSPORT TO BED FORMS AND TURBULENCE LEVELS

(*b*) California State University Foundation, Sacramento.
(*d*) Experimental; basic research.
(*e*) A constant-temperature anemometer with a conical probe is being used to obtain turbulence measurements in water flows over sand beds.
(*g*) Changes in turbulent and mean velocity profiles have been correlated with flow parameters and bed forms. The presence of high sediment concentrations appears to suppress the turbulence levels near the bed and to increase them nearer the surface.
(*h*) Discussion of **Experimental Investigation of Form of Bed Roughness,** S. D. Khanna, *J. of Hyd. Div., Proc. ASCE,* Oct. 1970., by A. L. Prasuhn, *J. of Hyd. Div., ASCE* **97**, pp. 1146-1148, July 1971.
Turbulence Measurements Over an Alluvial Bed, A. L. Prasuhn, R. Lerseth, *Sedimentation (Symp. to Honor Prof. H. A. Einstein),* pp. 7-1 to 7-15, 1972.
Turbulence Measurements Over Sand Beds, A. L. Prasuhn, *Proc. Intl. Symp. on River Mechanics,* Bangkok, Thailand, Jan. 1973.

023-08264-040-60

CIRCULATION IN THE SAN FRANCISCO BAY SYSTEM AND ITS EFFECTS ON DISPERSION

(*b*) Dept. of Water Resources, State of California.
(*c*) Richard J. Lerseth, Asst. Engineer, Dept. of Water Resources, Sacramento, Calif., or Dr. A. L. Prasuhn, Dept. of Civil Engrg., Calif. State Univ., Sacramento.
(*d*) Experimental, program development and operation of model, for Master's thesis.
(*e*) Determination of the circulation pattern and dispersion characteristics of the San Francisco Bay System due to tidal effect, wind, and Coriolis forces. Net effect of advective flows from rim sources.
(*f*) Discontinued.

(*h*) Included as a part of the *Dispersion Capability Study of San Francisco Bay-Delta Waters*, for the Calif. State Water Res. Control Bd. by Calif. Dept. of Water Resources under Interagency Agreement No. 9-2-23. Final Report, Publication No. 45, *A Study of Dispersion Capability of San Francisco Bay-Delta Waters*, R. Lerseth, A. Nelson, submitted to the Board in Aug. 1972.

023-08663-860-60

MATHEMATICAL SIMULATION OF THE SOUTHERN SAN JOAQUIN DELTA

(*b*) Department of Water Resources, State of California.
(*c*) Richard J. Lerseth, Registered Engr., Dept. of Water Resources, Sacramento, Calif., or Dr. A. L. Prasuhn, Dept. of Civil Engrg., Calif. State Univ., Sacramento.
(*d*) Experimental, program development and operation of the model for Master's thesis.
(*e*) Determine the stress placed upon the Southern San Joaquin Delta by export of water to San Joaquin Valley, San Francisco Bay Area, and Southern California.

UNIVERSITY OF CALIFORNIA, BERKELEY, College of Engineering, Department of Civil Engineering, Division of Hydraulic and Sanitary Engineering, Berkeley, Calif. 94720. Professor J. W. Johnson.

024-02265-030-00

FORCES ON ACCELERATED CYLINDERS

(*c*) Professor A. D. K. Laird.
(*d*) Experimental and theoretical; basic research.
(*e*) Measurement and prediction of drag coefficients and flow configurations about cylinders in fluids, including effects of support flexibility.
(*g*) Analytical explanation of eddy formation found.

024-04930-410-11

COASTAL SAND MOVEMENT

(*b*) U.S. Army Coastal Engrg. Res. Center.
(*d*) Experimental; laboratory and field.
(*e*) This investigation is concerned with the transportation of sand by both wind and waves.
(*f*) Discontinued.
(*h*) **River Mouth and Beach Sediments – Yankee Point to Hurricane Point, and Grain Size Analyses,** P. Pause, K. Leslie, P. Wilde, P. Henshaw, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL-2-37*, 22 pp. 1972.
Recent Sediments of the Central California Continental Shelf – Pillar Point to Pigeon Point, Part C. Interpretation and Summary of Results, P. Wilde, J. Lee, T. Yancey, M. Glogoczowski, *Univ. of Calif. Hyd. Engrg. Lab. Rept. HEL-2-38*, 83 pages, 1973.
Sediment Transport Due to Oscillatory Waves, T. C. MacDonald, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL-2-39*, 98 pages, 1973.

024-04934-420-11

WAVE DIFFRACTION AND REFRACTION

(*b*) U.S. Army Coastal Engrg. Res. Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Determination by model tests of diffraction and refraction characteristics of wind waves. Computer simulation program for waves with directional spectra.
(*f*) Completed.
(*g*) A study was made on the directional spectra of wind generated waves, and on their diffraction by a semi-infinite breakwater. Theoretical studies are being conducted on the properties of direction of wave spectra, and methods of simulating such waves on a digital computer.
(*h*) **Excitation of Waves Inside a Bottomless Harbor,** N. Sakuna, J. Bühler, R. L. Wiegel, *Proc. 13th Coastal Engrg. Conf., ASCE* **III**, Ch. 114, July 10–14, 1972, Vancouver, B. C., Canada, pp. 2005-2023.
Wave Response of Bottomless Harbors and Offshore Oil Storage Tanks, H. Raissi, *Ph.D. Thesis*, Dept. of Civil Engrg.; also *Tech. Rept. No. HEL 1-21*, Hyd. Eng. Lab., Jan. 1973, 158 pages.
Wave Oscillations in an Offshore Oil Storage Tank, H. Raissi, *Proc. 14th Conf. Coastal Engrg., ASCE*, June 24-28, 1974, Copenhagen, Denmark, Ch. 117 (in press).

024-05439-430-11

WAVE FORCES

(*b*) U.S. Army Coastal Engrg. Res. Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Determine by model tests the forces exerted by waves on coastal structures, including pipelines. Theoretical studies of statistical properties of wave forces.
(*f*) Completed.
(*g*) Forces exerted by waves on pipelines are being studied experimentally. The relationship between the Keulegan number, the longitudinal and transverse forces exerted by waves on piles is also being studied in the laboratory.
(*h*) **Forces on Submerged Pipelines Induced by Water Waves,** M. F. Al-Kazily, *Ph.D. Thesis*, Dept. of Civil Engrg.; also *Tech. Rept. HEL 9-21*, Hyd. Eng. Lab., Oct. 1972, 197 pages.
Forces Exerted by Waves Breaking Seaward of a Vertical Wall, C. Delmonte, *Hyd. Eng. Lab. Tech. Rept. HEL 9-20*, June 1972, 29 pages.
Wave Forces on Offshore Structures, F. M. Abdel-Aal, *Egyptian Soc. of Engrg. J.*, Dec. 1972, pp. 1-8.
Wave Forces on Pipelines, M. F. Al-Kazily, *Proc. 14th Conf. Coastal Engrg.*, June 24-28, 1974, Copenhagen, Denmark, ASCE, Ch. 109 (in press).
Wave-Induced Eddies and "Lift" Forces on Circular Cylinders, R. L. Wiegel, R. C. Delmonte, *Proc. 9th ONR Symp. Naval Hydrodynamics*, Paris, France, Aug. 20-25, 1972, Ch. 15 (in press).

024-06224-420-11

TSUNAMIS

(*b*) U.S. Army Coastal Engrg. Res. Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Model and theoretical studies of water waves generated by horizontal fault moving normal to a channel or escarpment, and generated by a rockfall into a reservoir.
(*f*) Completed.
(*g*) See (e).
(*h*) **Three-Dimensional Hydraulic Model Study of Water Waves Generated by Horizontal Tectonic Displacements,** S.-L. Liu, R. L. Wiegel, *Hyd. Eng. Lab. Tech. Rept. HEL 6-10*, Dec. 1974, 43 pages.

024-07149-060-36

MANAGEMENT OF WATER QUALITY IN STRATIFIED RESERVOIRS

(*b*) Environmental Protection Agency.
(*c*) Hugo B. Fischer, Professor.
(*d*) Experimental and theoretical; basic research.
(*e*) A study has been made of the distribution of water inserted into a stratified reservoir, and the resulting flow patterns.
(*f*) Complete.
(*h*) **Flow into a Stratified Reservoir,** A. A. Zuluaga-Angel, R. B. Darden, H. B. Fischer, *EPA Rept. R2-72-037*, 8/72, 65 pp., Washington, D. C., 1972.

024-07150-820-54

OPTIMAL DETERMINATION OF STRATIFIED GROUNDWATER BASIN CHARACTERISTICS

(*b*) Natl. Science Found.; Water Resources Center.

(*c*) D. K. Todd.
(*d*) Theoretical; applied research.
(*e*) To estimate from historical data, values of S and T for individual wells in a given configuration for the purpose of optimal management of the basin. A computational algorithm will be designed, and it is proposed to solve it by decomposition because of its high dimensionality.
(*f*) Completed.

024-07151-870-61

WASTE DISPOSAL SYSTEMS

(*b*) Water Resources Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental, basic and applied research.
(*e*) Perform model studies of the mixing processes associated with sewage effluent being discharged on ocean bottom and buoyant power plant cooling water being discharged at ocean surface.
(*g*) Model studies of the effects of wind-generated waves on the mixing of buoyant jets are being made.
(*h*) **Mixing of Merging Buoyant Jets from a Manifold on Stagnant Receiving Water of Uniform Density,** P. Liseth, *Proc. 6th Intl. Conf. Advances in Water Pollution Research*, Jerusalem, Israel, June 18-23, 1972, AAWPR, Pergamon Press, 1973, pp. 921-936.
Velocity and Temperature in a Buoyant Surface Jet, R. Dornhelm, M. Nouel, R. L. Wiegel, *J. Power Div., Proc. ASCE* **98,** PO1, June 1972, pp. 29-47.
Model Studies of Multiport Outfalls in Unstratified, Stagnant or Flowing Receiving Water, J. Bühler, *Ph.D. Thesis*. Dept. of Civil Engrg., Jan. 1974, page 164.
A Note on the Diffusion Due to Linearized Random Waves, T. Nobuyuki, *Proc. Japan Soc. Civil Engrg.* **181,** Sept. 1970, pp. 101-105.

024-08046-870-61

THE MECHANICS OF HEAT DISPOSAL IN STREAMS AND ESTUARIES

(*b*) Water Resources Center, Univ. of California; National Science Foundation.
(*c*) Hugo B. Fischer, Professor.
(*d*) Experimental; basic research.
(*e*) Experiments are being conducted in a new tidal flume 1,000 ft long and 12 ft wide. The experiments are to determine the effect of various geometries on longitudinal and transverse dispersion in partially mixed estuaries.
(*h*) **Transverse Dispersion of Pollutants in Estuaries,** P. R. B. Ward, H. B. Fisher, *Proc. 15th Congr. Intl. Assoc. for Hydraulic Res.* **2,** Istanbul, Turkey, 113-120, 1973.
Discussion of **Minimum Length of Salt Intrusion in Estuaries** by Ben P. Rigter, H. B. Fischer, *J. Hyd. Div., Proc. ASCE* **100,** HY5, 708-712, 1974.
Effect of Stream Turbulence on Heated Water Plumes, J. Weil, H. B. Fischer, *J. Hyd. Div., Proc. ASCE* **100,** HY7, 951-970, 1974.
A Laboratory Study of Estuarine Salinity Instrusion in a Rectangular Channel of Large Aspect Ratio, D. G. Daniels, *Waste Heat Management Rept. 17*, Hyd. Eng. Lab., Univ. of Calif., Berkeley.

024-08047-410-11

TIDAL INLETS ON SANDY SHORELINES

(*b*) Corps of Engineers, U.S. Army, Coastal Engrg. Res. Center.
(*d*) Experimental; laboratory and field; applied research.
(*e*) This investigation is concerned with the hydraulic and physical characteristics of tidal inlets on sandy shorelines.
(*f*) Discontinued.
(*h*) **A Case History of Santa Cruz Harbor, California,** J. T. Moore, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL-24-15*, 42 pages, 1973.
Bolinas Lagoon Inlet, California, J. W. Johnson, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL-24-15*, 44 pages, 1973.
Hydraulics of Tidal Inlets on Sandy Coasts, E. Mayor-Mora, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL-24-16*, 241 pages, 1973.

024-08781-520-60

STUDY OF TOMALES "SNEAKER WAVE"

(*b*) California State Divsion of Navigation and Ocean Development, and University of California Sea Grant.
(*c*) Hugo B. Fischer, Professor.
(*d*) Experimental and field investigation.
(*e*) An attempt is being made to discover the cause of frequent boating accidents at the mouth of Tomales Bay, which are frequently ascribed to a mysterious "sneaker wave."

024-08782-420-11

EFFECT OF LARGE NEARSHORE STRUCTURES ON WAVE MOTION IN THE VICINITY OF THE STRUCTURE AND ADJACENT COAST

(*b*) Corps of Engineers, U. S. Army, Coastal Engineering Research Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Studies are made of the characteristics of waves diffracted by offshore structures such as a man-made island, in order to determine their effect on the coastline.
(*f*) Completed.
(*h*) **Effect of Large Nearshore Structures on Wave Motion in the Vicinity of the Structure and Adjacent Coast,** V. W. Harms, H. T. Sun, R. L. Wiegel, A. Kian, *Hyd. Eng. Lab. Tech. Rept., HEL 9-21*, Jan. 1974, 140 pages.

024-08783-420-11

WAVE FORCES ON PIPELINES AT OR NEAR THE BOTTOM

(*b*) Corps of Engineers, U. S. Army, Coastal Engineering Research Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Studies are made of the forces exerted by waves on a pipeline at or near the bottom.

024-08784-870-73

HYDRAULIC MODEL STUDY OF THE COOLING WATER SYSTEM PROPOSED FOR DIABLO CANYON FOR THE PURPOSE OF DETERMINING THE VALIDITY OF SUCH A MODEL TO PREDICT THE PROTOTYPE FOR VARIOUS OCEANIC CONDITIONS

(*b*) Pacific Gas and Electric Company.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental.
(*e*) An undistorted 1:75 scale model of a 1,000 megawatt power plant cooling water system has been designed and constructed to perform a densimetric Froude model study of the mixing characteristics of the system.

024-08785-220-54

SEDIMENT TRANSPORT IN NONSTEADY FLOW

(*b*) National Science Foundation.
(*c*) J. A. Harder, Professor of Hydraulic Engineering.
(*d*) Experimental, applied research, Ph.D. thesis.
(*e*) Investigate how sediment behaves in nonsteady flows.
(*f*) Completed.
(*g*) A significant finding was that there seemed to be a strong inherent instability, with periods on the order of ten to thirty minutes, in the sediment transport rate and depth when the energy slope and discharge were held constant within about 5 percent. This is attributed to interactions between the flow and the sediment.
(*h*) **Sediment Transport in Nonsteady Flow,** D. M. Gee, *Hyd. Lab. Rept. HEL 22-3*, 93 pp, 1973. Also *Ph.D. Thesis*, Dept. Civil Engrg., Univ. Calif., Berkeley.

024-08786-220-60

SEDIMENT EXCLUSION AT RIVER DIVERSIONS

(*b*) California Dept. of Water Resources.
(*c*) J. A. Harder, Professor of Hydraulic Engineering.
(*d*) Experimental and theoretical, applied research, Ph.D. thesis.
(*e*) Predict sediment distribution between a river diversion and the downstream portion of the diversion, including cases in which the flow was subject to tidal reverses.
(*f*) Completed.
(*g*) Special computer programs predicted the formation of a large bar in the river downstream from the diversion.
(*h*) **Sediment Exclusion at River Diversions,** J. I. Ordonez, *Hyd. Engr. Res. Rept. HEL 22-4*, 154 pages, 1974. Also *Ph.D. Thesis*, Dept. Civil Engrg., Univ. Calif., Berkeley.

UNIVERSITY OF CALIFORNIA, LOS ANGELES, School of Engineering and Applied Science, Engineering Systems Department, Los Angeles, Calif. 90024. Professor Moshe Rubinstein, Department Chairman.

025-07201-800-33

OPTIMIZATION OF WATER RESOURCES DEVELOPMENT: PHASE II.

(*b*) Office of Water Resources Research (now the Office of Water Research and Technology), USDI.
(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) A comparative evaluation will be made of the use of "critical period hydrologies" to develop optimum operating policies as contrasted to more sophisticated but more expensive analytical procedures. The preceding project has used a critical period of seven dry years (1928-1934), and decisions on firm outputs have been based on this. This will be examined to evaluate the extent to which conclusions based on it depart from those using other methods. It will be evaluated first on simple systems and then later applied to large integrated systems.
(*f*) Completed.
(*g*) See Publications.
(*h*) **Optimization of Multiple Reservoir System,** W. J. Trott, W. W-G. Yeh, *J. Hydraul. Div., ASCE* 99, HY10, Oct. 1973, pp. 1865-1884.
Optimization of Water Resources Development: Optimization of Capacity Specifications for Components of Regional, Complex, Integrated, Multi-Purpose Water Resources Systems, *USLA-ENG-7245*, June 1972.

025-07928-820-00

OPTIMAL MANAGEMENT OF LEAKY AQUIFER SYSTEMS

(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) Investigate and test the applicability of control theoretic techniques for optimal management of leaky aquifer systems. The hydraulic conductivities as well as the storage coefficient of the system are generally unknown and are to be identified from field pumping data. Identification of the mathematical structures of layered aquifers is an essential prerequisite for efficient management of ground water basins.
(*f*) Completed.
(*h*) **Nonsteady Flow in a Recharge Well-Unconfined Aquifer System,** M. A. Marino, W. W-G. Yeh, *J. Hydrology* **16**, 1972, 159-176.
A Discrete Space Continuous Time Modeling Approach to Nonsteady Flow in a Leaky Aquifer System of Finite Configuration, M. A. Marino, W. W-G. Yeh, *J. Hydrology* **20**, 1973, 255-266.
Identification of Parameters in Finite Leaky Aquifer System, M. A. Marino, W. W-G. Yeh, *J. Hydraul. Div., ASCE* **99**, HY2, Feb. 1973, pp. 319-336.
On the Optimal Identification of Parameters in a Parabolic System, W. W-G. Yeh, presented at the *48th Ann. Fall Mtg. of the SPE of AIME*, Paper No. SPE 4547, Las Vegas, Nev., Sept. 30-Oct. 3, 1973.
Identification of Parameters in an Inhomogeneous Aquifer by Use of the Maximum Principle of Optimal Control and Quasilinearization, A. C. Lin, W. W-G. Yeh, *Water Resources Research* **10**, 4, Aug. 1974, pp. 819-838.
Invariant Imbedding and Unsteady Ground-Water Flow, S. Chang, W. W-G. Yeh, *J. Hydraul. Div., ASCE* **100**, HY10, Oct. 1974 pp. 1343-1352.
Optimal Identification of Parameters in an Inhomogeneous Medium with Quadratic Programming, presented at the *49th Ann. Fall Mtg. of the SPE of AIME*, Paper No. SPE 5021, Houston, Tex., Oct. 6-9, 1974.
Linear Programming and Channel Flow Identification, W. W-G. Yeh, L. Becker, *J. Hydraul. Div., ASCE* **99**, HY11, Nov. 1973, pp. 2013-2021.
Identification of Aquifer Parameters in a Finite Leaky Artesian System, M. A. Marino, *Ph.D. Dissertation* directed by W. W-G. Yeh, Schl. Engrg. and Appl. Sci., UCLA, Nov. 1972.
Optimal Identification of Aquifer Parameters in a Distributed System, A. C. Lin, *Ph.D. Dissertation* directed by W. W-G. Yeh, Schl. of Engrg. and Appl. Sci.., UCLA, Mar. 1973.
A Quadratic Programming Solution of the Inverse Problem in Unsteady Groundwater Flow, S. Chang, *Ph.D. Dissertation* directed by W. W-G. Yeh, Schl. of Engrg. and Appl. Sci., UCLA, Sept. 1974.

025-07929-860-00

PROBABILISTIC MODELS IN THE DESIGN AND OPERATION OF A MULTIPURPOSE RESERVOIR SYSTEM

(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) To develop analytical probabilistic models for the optimal operation and design of water resource systems. Such a model is important especially in view of the stochastic nature of the input hydrology.
(*f*) Completed.
(*g*) See publications.
(*h*) **Probabilistic Models in the Design and Operation of a Multi-Purpose Reservoir System,** S. Arunkumar, W. W-G. Yeh, *Water Resources Center Contribution No. 144*, Univ. of Calif., Davis, Dec. 1973.

025-08699-860-00

PREINVESTMENT PLANNING: OPTIMAL TIMING AND SEQUENCE OF BUILDING MULTI-PURPOSE, MULTI-STAGE, MULTI-FACILITY WATER RESOURCE SYSTEMS

(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) To develop mathematical models and the corresponding computer programs for preinvestment planning and optimality of time, sequence and number of stages which will be constructed for multi-purpose, multi-stage, multi-facility water resource systems. The specific objective of optimization is to minimize the present worth and at the same time meet the projected demands for every time period during the time horizon of the development.
(*f*) Completed.
(*g*) See publications.
(*h*) **Optimal Timing, Sequencing, and Sizing of Multiple Reservoir Surface Water Supply Facilities,** L. Becker, W. W-G. Yeh, *Water Resour. Res.* **10**, 1, Feb. 1974, pp. 57-62.
Timing and Sizing of Complex Water Resource Systems, L. Becker, W. W-G. Yeh, *J. Hydraul. Div., ASCE* **100**, HY10, Oct. 1974, pp. 1457-1470.

025-08700-860-31

OPTIMAL STATE ANALYSIS OF RESERVOIRS

(*b*) Bureau of Reclamation, USDI, Sacramento, Calif.
(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) To develop criteria for the optimal real-time monthly operation for the California Central Valley Project with due regard to water supply and power generation. The analysis maintains a parametric capability for inclusion of such purposes as flood control, recreation, fish and wildlife enhancement, etc., to be maintained at the maximum extent feasible.
(*g*) See publications.
(*h*) **Optimal State Analysis of Reservoirs,** W. W-G. Yeh, et al., *UCLA-ENG-7390*, Nov. 1973, Univ. of Calif., Los Angeles.
Optimization of Real-Time Operation of a Multiple Reservoir System, L. Becker, W. W-G. Yeh, *Water Resour. Res.*, Dec., 1974.

025-08701-860-33

OPTIMIZATION OF REAL TIME DAILY OPERATION OF A MULTIPLE-RESERVOIR SYSTEM

(*b*) Office of Water Resource and Technology, USDI.
(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) To develop practical procedures for the analysis of The California Central Valley Project Reservoir System to guide real-time daily decisions concerning the optimal operation of this reservoir system with due regard to multiple-purpose objectives involved and the problems related to hydrologic uncertainties.

UNIVERSITY OF CALIFORNIA, LOS ANGELES, School of Engineering and Applied Science, Mechanics and Structures Department, Los Angeles, Calif. 90024. Dr. Robert E. Kelly.

026-07930-060-54

INTERNAL HYDRAULIC JUMPS

(*b*) National Science Foundation.
(*c*) Dr. Robert E. Kelly or Dr. S. C. Mehrotra, 905 S. Idaho, Apt. 114, La Habra, Calif. 90631.
(*d*) Theoretical and experimental, basic research (Ph.D. thesis).
(*e*) Investigation of uniqueness of internal hydraulic jumps; comparison of results for a two-fluid model to experiments concerning miscible fluids.
(*f*) Completed.
(*g*) The question of non-uniqueness in internal hydraulic jumps can be resolved without solving the initial value problem. Experimental results are obtained which serve to delimit the applicability of the two-fluid model from the viewpoints of interfacial shear and turbulent entrainment.
(*h*) **On the Question of Non-Uniqueness of Internal Hydraulic Jumps and Drops in Two-Fluid System,** S. C. Mehrotra, R. E. Kelly, *Tellus* **XXV**, 6, 560-567, 1973.
Limitations on the Existence of Shock Solutions in a Two-Fluid System, S. C. Mehrotra, *Tellus* **XXV**, 2, 169-173, 1973.
Circular Jumps, S. C. Mehrotra, *J. Hydraulics Div., ASCE* **100,** HY8 1133-40, 1974.
Boundary Contractions as Controls in Two-Layer Flows, S. C. Mehrotra, *J. Hydraulics Div., ASCE* **99,** HY11, 2003-12, 1973.
An Alternative Formulation of the Problem of Density Jumps, S. C. Mehrotra, *Tellus* **26,** 5, 128-130, 1974.

026-07931-060-54

STABILITY OF BUOYANCY INDUCED FLOWS IN A STRATIFIED FLUID

(*b*) National Science Foundation.
(*c*) Dr. Robert E. Kelly or Dr. P. A. Iyer, 5860 Dirac St., San Diego, Calif. 92122.
(*d*) Theoretical, basic research; Ph.D. thesis.
(*e*) The stability of flows induced by a heated or cooled inclined surface, with an ambient, quiescent stratified fluid outside the boundary layer, are investigated by numerical methods.
(*f*) Completed.
(*g*) The mode of two-dimensional, progressive waves is found to be predominant for all angles of inclination. The thermal convection mode (spanwise rolls) is found to be always more stable. Supercritical finite-amplitude states are calculated.
(*h*) **Instabilities in Buoyancy-Driven Boundary-Layer Flows in a Stably Stratified Medium,** P. A. Iyer, *Boundary-Layer Meteorology* **5,** 53-66, 1973.
The Stability of the Laminar Free Convection Flow Induced by a Heated Inclined Plate, P. A. Iyer, R. E. Kelly, *Intl. J. Heat and Mass Transfer* **17,** 517-525, 1974.

026-08668-090-00

THERMAL CONVECTION IN A FLUID LAYER WITH NONUNIFORM HEATING OR THICKNESS

(*d*) Theoretical, experimental, basic research (Ph.D. thesis).
(*e*) Convection in a layer with surfaces whose temperatures vary in space are more typical of many environmental situations than constant temperature surfaces. The critical Rayleigh number is being calculated. The case of varying layer thickness is rather analogous and is easirer to investigate theoretically.
(*g*) Results are being obtained for the case when the horizontal length scale, over which the temperature varies, is much larger than the average depth of the fluid layer.

026-08669-090-00

NONLINEAR INSTABILITY OF THERMAL CONVECTION ROLLS IN A SHEAR FLOW

(*b*) U. S. Army Research Office – Durham.
(*d*) Theoretical, basic research.
(*e*) Convection first appears in a statically unstable fluid with a shear in the form of convection rolls whose axes are in the direction of the mean flow. However, these finite-amplitude equilibrium states can also become unstable, and the critical values of Reynolds and Rayleigh numbers for this to occur are being computed.

UNIVERSITY OF CALIFORNIA, SAN DIEGO, Institute of Geophysics and Planetary Physics, La Jolla, Calif. 92037. Drs. Walter Munk and James Brune, Associate Institute Directors.

027-05927-420-20

DEEP SEA TIDES

(*b*) Office of Naval Research and National Science Foundation.
(*c*) Dr. Walter Munk and Bernard Zetler.
(*d*) Field investigation, theoretical analysis, basic research.
(*e*) Bottom pressure measurements at four MODE stations constitute a unique set of deep-sea tidal measurements, although the instruments were deployed for other purposes.
(*f*) Completed.
(*g*) The tidal data permitted an evaluation of cotidal charts of the area, calculation of tidal currents, and estimates of the energy level of nonlinear tides in mid-ocean. Related research optimized tidal analysis procedures.

027-07932-420-20

INTERNAL WAVES AND MICROSTRUCTURE

(*b*) Office of Naval Research and Advanced Research Projects Agency.
(*c*) Drs. Walter Munk, Frank Snodgrass, James Cairns, and Gordon Williams.
(*d*) Field investigations, theoretical analysis, basic research for Ph.D.
(*e*) A neutrally-buoyant float with programmed or surface-controlled variable density (yo-yo) is used to obtain repeated thermal microstructure profiles over a 20 m segment of the water column.
(*g*) Profiling while drifting reduces the Doppler and fine-structure effects which usually contaminate internal wave measurements. The resulting vertical displacement spectra decrease generally as τ^{-2} up to the local Brunt-Väisälä frequency; beyond this, the spectra drop sharply to low levels. Vertical coherence of internal waves over a separation of 100 m was found to be 0.8, fairly independent of frequency up to the Brunt-Väisälä frequency. Internal wave models have been compared with the data. Lenses of high microstructure activity, many db higher than the structure above and below the lenses, have been traced by successive crossings and shown to move up and down with internal waves (as indicated by mean isotherms).
(*h*) **Internal Wave Measurements From a Midwater Float,** J. L. Cairns, *Ph.D. Dissertation*, Univ. of Calif., San Diego, 1974.
Microstructure and Internal Wave Measurements from a Midwater Float, G. W. Williams, *Ph.D. Dissertation*, Univ. of Calif., San Diego, 1974.
Oceanic Mixing by Breaking Internal Waves, C. J. R. Garrett, W. H. Munk, *Deep-Sea Research* **19,** 823-832, 1972.
Internal Waves and Microstructure (the Chicken and the Egg), W. H. Munk, C. J. R. Garrett, *Boundary Layer Meteorology* **4,** 37-45, 1973.
Space-Time Scales of Internal Waves: A Progress Report, C. J. R. Garrett, W. H. Munk, *J. Geophys. Res.*, Jan. 1975.
Internal Wave Measurements from a Midwater Float, J. L. Cairns, *J. Geophys. Res.*, Jan. 1975.

027-08664-450-20

OCEAN BOTTOM PRESSURES AND TEMPERATURES

(*b*) Office of Naval Research and National Science Foundation.
(*c*) Dr. Walter Munk, Dr. Frank Snodgrass, Bernard Zetler.
(*d*) Field investigation and theoretical analysis, basic research.
(*e*) As part of MODE (Mid-Ocean Dynamics Experiment), bottom pressure and temperature sensors were dropped to the seafloor during five months in 1973 at three locations. Also participated in bottom pressure intercalibration experiment in late 1973 off Brest, France, under auspices of SCOR-IAPSO-UNESCO Working Group No. 27, Tides of the Open Ocean.
(*f*) Completed.
(*g*) MODE bottom pressure array showed pressure fluctuations with a horizontal coherence scale of several thousand kilometers, much greater than the 100-km scale of MODE eddies.
(*h*) **Bottom Pressures in the MODE Region,** W. Brown, W. Munk, F. Snodgrass, B. Zetler, *MODE Hot Line News* **37,** 1, 1973.
IGPP Measurements of Bottom Pressure and Temperature, F. Snodgrass, W. Brown, W. Munk, *J. Phys. Oceanogr.*, Jan. 1975.
MODE Bottom Experiment, W. Brown, W. Munk, F. Snodgrass, H. Mofjeld, B. Zetler, *J. Phys. Oceanogr.*, Jan. 1975.
Evaluation of Deep Sea Tide Gauge Sensor, F. E. Snodgrass, M. H. Wimbush, *Proc. IEEE Intl. Conf. Engrg. in the Ocean Environment*, Halifax, N. S., **I,** 350-353, 1974.
Deep-Sea Pressure-Temperature Measurements in the Pacific, *MODE Hot Line News* **18,** 3, 1972.

UNIVERSITY OF CALIFORNIA, SAN DIEGO, Scripps Institution of Oceanography, (see SCRIPPS INSTITUTION OF OCEANOGRAPHY listing).

CHICAGO BRIDGE AND IRON COMPANY, Marine Research and Development, Route 59, Plainfield, Ill. 60544. Mr. W. A. Tam, Director.

028-09013-420-00

WAVE FORCES ON SUBMERGED OBJECTS

(*c*) Dr. S. K. Chakrabarti, Analytical Head.
(*d*) Theoretical, experimental, and encompasses both basic and applied research.
(*e*) Development of mathematical model and computer programs to predict the forces on basic components of offshore drilling platforms and storage tanks; data obtained experimentally to validate the theoretical models, determine hydrodynamic coefficients and flow characteristics around submerged objects. Projects include developing potential flow theory for large objects, inertia and drag forces and lift forces on small tubular members in random orientation.
(*h*) **Mechanical Excitation of Offshore Tower Model,** C. P. Rains, S. K. Chakrabarti, *J. Waterways, Harbors and Coastal Eng. Div., ASCE* **98,** Feb. 1972.
Nonlinear Wave Forces on Vertical Cylinder, S. K. Chakrabarti, *J. Hydraulics Div., ASCE* **98,** Nov. 1972.
Wave Forces on Submerged Objects of Symmetry, S. K. Chakrabarti, *J. Waterways, Harbors and Coastal Eng. Div., ASCE* **99,** May 1973.
Gross and Local Wave Loads on a Large Vertical Cylinder – Theory and Experiment, S. K. Chakrabarti, W. W. Tam, *Proc. Offshore Tech. Conf.*, Houston, Texas, Paper No. OTC 1818, May 1973.
Wave Forces on Vertical Cylinder Including Diffraction and Viscous Effects, S. K. Chakrabarti, *J. Hydraulics Div., ASCE* **99,** Aug., 1973.
Nonlinear Wave Forces on Halfcyclinder and Hemisphere, S. K. Chakrabarti, R. A. Naftzger, *J. Waterways, Harbors and Coastal Eng. Div., ASCE* **100,** Aug., 1974.
Wave Interaction with Large Vertical Cylinder, S. K. Chakrabarti, W. A. Tam, *J. Ship Research*, Mar. 1975.
Wave Height Distribution over Vertical Cylinder, S. K. Chakrabarti, W. A. Tam, *J. Waterways, Harbors and Coastal Eng. Div., ASCE* **101,** May, 1975.
Wave Forces on Fixed Offshore Structure, S. K. Chakrabarti, *ASCE National Structural Eng. Convention*, New Orleans, La., Apr. 1975.
Wave Forces on a Randomly Oriented Tube, S. K. Chakrabarti, W. A. Tam, A. L. Wolbert, *Proc. Offshore Tech. Conf.*, Houston, Tex., May 1975.
Wave Forces on a Submerged Hemispherical Shell, R. A. Naftzger, S. K. Chakrabarti, *Proc. Conf. Ocean Eng. III, ASCE*, Newark, Del., June, 1975.

UNIVERSITY OF CINCINNATI, Department of Chemical and Nuclear Engineering, Cincinnati, Ohio 45221. Dr. D. B. Greenberg, Department Head.

029-07227-130-52

BOILING AND TWO-PHASE FLOW STUDIES

(*b*) U. S. Atomic Energy Commission.
(*c*) Dr. Joel Weisman.
(*d*) Experimental and theoretical, basic and applied research, M.S. and Ph.D. theses.

(*e*) Study of flow properties of vapor-liquid mixtures under steady state and transient conditions. Application to water cooled nuclear power reactor during accident conditions.
(*g*) Two-phase pressure drops across abrupt area changes have been determined in the Freon-Freon vapor system. These steady-state pressure drops, plus those from the literature, were found to be described by equations based on one-dimensional momentum theory. The conditions under which homogeneous flow may be assumed have been determined. Oscillatory flow experiments have shown that one-dimensional momentum theory reasonably predicts transient two-phase flow behavior across area changes.
(*h*) **The Applicability of the Homogeneous Flow Model to Flow in Straight Pipes and Across Abrupt Area Changes,** A. Husain, J. Weisman, *USAEC Report COO-21512-15*, Dec. 1974.

029-07228-130-00

FOAM DRAINAGE AND OVERFLOW

(*c*) Dr. Robert Lemlich.
(*d*) Experimental and theoretical, basic and applied research, Ph.D. theses.
(*e*) The behavior of liquid foam with regard to its coalescence, interstitial drainage, liquid content, and bulk flow. Applications to foam fractionation, drainage, and flow.
(*h*) **Coalescence and Conductivity in Dynamic Foam,** I. J. Jashnani, R. Lemlich, *Ind. Eng. Chem. Fund.*, in press.
Countercurrent Foam Fractionation at High Rates of Throughput by Means of Perforated Plate Columns, G. A. Aguayo, R. Lemlich, *Ind. Eng. Chem. Process Design Development* **13,** 153-159, 1974.
Foam Drainage, Surface Viscosity, and Bubble Size Bias, I. L. Jashnani, R. Lemlich, *J. Coll. Interface Sci.* **46,** 13-16, 1974.
The Adsorptive Bubble Separation Techniques, R. Lemlich, 211-223 in *Traces of Heavy Metals in Water, Removal Processes and Monitoring*, J. E. Sabadell, ed., Symp. at Princeton Univ., USEPA, Nov. 1973.
Transfer Units in Foam Fractionation, I. L. Jashnani, R. Lemlich, *Ind. Eng. Chem. Process Design Development* **12,** 312-321, 1973.
Adsorptive Bubble Separation Methods, R. Lemlich, **17,** 29-34 in *Chemical Engineering Handbook*, R. H. Perry, C. H. Chilton, eds., McGraw-Hill, 1973.
Some Physical Aspects of Foam, R. Lemlich, *J. Cosmetic Chem.* **23,** 299-311, 1972.
Adsubble Methods, R. Lemlich, 113-127 in *Recent Developments in Separation Science* **1,** N. N. Li, ed., Chemical Rubber, Cleveland, Ohio, 1972.

029-07937-150-00

BUBBLE FRACTIONATION

(*c*) Dr. Robert Lemlich.
(*d*) Experimental and theoretical, basic and applied research, M.S. thesis.
(*e*) A study of the vertical segregation of components that occurs within a liquid as a result of adsorption at the surfaces of rising bubbles. Possible application to water pollution control and to natural bubble processes in sea and lakes.
(*h*) **A Theoretical Study of Bubble Fractionation,** K. D. Cannon, R. Lemlich, *Chem. Eng. Prog. Symp. Ser.* **68,** 124, 180-184, 1972.

029-07938-140-50

BOILING DURING PRESSURE TRANSIENTS

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. Joel Weisman.
(*d*) Experimental and theoretical, basic and applied research, M.S. theses.
(*e*) Study of departure from thermodynamic equilibrium during pressure transients.
(*f*) Suspended.
(*h*) **The Initiation of Boiling During Pressure Transients,** J. Weisman, G. Bussell, T. Hsieh, *J. Heat Transfer, Trans. ASME* **96,** Series C, p. 553, 1974.

029-08670-130-54

FLOW PATTERNS IN HORIZONTAL AND NEAR HORIZONTAL PIPES

(*b*) National Science Foundation.
(*c*) Dr. Joel Weisman.
(*d*) Experimental and theoretical, basic research, Ph.D. theses.
(*e*) Experimental and analytical study of the transitions between flow patterns in concurrent vapor-liquid flow.
(*h*) **Flow Patterns and Pressure Drop in Vapor-Liquid Flow,** W. G. Choe, J. Weisman, Sept. 1974. National Technical Information Service, Accession No. PB-237261A5.

UNIVERSITY OF CINCINNATI, Department of Civil and Environmental Engineering, Hydraulic Laboratory, Cincinnati, Ohio 45221. Dr. L. M. Laushey, Head, Civil and Environmental Engineering Department, Dr. H. C. Preul, Directing Head, Hydraulic Laboratory.

031-06462-070-00

UNSTEADY FLOW

(*c*) Dr. Louis M. Laushey.
(*d*) Experimental and theoretical; Doctoral dissertation.
(*e*) Measurements in groundwater tank and Hele-Shaw apparatus to confirm equations for unsteady flow and to determine the friction during unsteady flow.
(*h*) Progress report, *Proc. IASH Symp.*, Bern, Switzerland, Oct. 1967.

031-06464-820-73

MODEL OF GROUNDWATER BASIN

(*b*) Southwestern Ohio Water Company.
(*c*) Dr. Louis M. Laushey and Mr. Robert C. Lewis.
(*d*) Experimental and theoretical.
(*e*) An analog computer solution and a mathematical model have been developed for an aquifer in the Miami River basin. Objective is to develop criteria and methods for the optimum management of the aquifer.
(*h*) Progress report, *Proc. 13th Congr. IAHR*, Paper A54, (Kyoto), Aug.-Sept. 1969.

031-07229-870-36

URBAN RUNOFF CHARACTERISTICS

(*b*) Environmental Protection Agency.
(*c*) Dr. Herbert C. Preul.
(*d*) Theoretical; field measurements; computer modeling.
(*e*) Field data collected from large urban watershed for development and testing of storm water management models.
(*h*) Interim 1st-year report, *EPA Water Poll. Control Res. Series*, 11024 DQU 10/70, Oct. 1970.
Assessment of Urban Runoff Quantity and Quality, H. C. Preul, *Proc. Intl. Sem. Water Resources Instrumentation*, Chicago, June 1974; available from Intl. Water Resources Assoc., P. O. Box 5691, Milwaukee, Wis. 53211.
Infiltration and Antecedent Precipitation, C. N. Papadakis, H. C. Preul, *J. Hydraulics Div., ASCE*, Oct. 1973.
Testing of Methods for Determination of Urban Runoff, C. N. Papadakis, H. C. Preul, *J. Hydraulics Div., ASCE* **99,** Oct. 1973.
Development of Design Storm Hyetographs for Cincinnati, Ohio, H. C. Preul, C. N. Papadakis, *Water Resources Bull.*, American Water Resources Assoc., Apr. 1973.
University of Cincinnati Urban Runoff Model, C. N. Papadakis, H. C. Preul, *J. Hydraulics Div., ASCE* **98,** Oct. 1972.
Final report in preparation, 1974.

031-07934-870-41

TRAVEL OF POLLUTION THROUGH AN AQUIFER

(*b*) U.S. Public Health Service.
(*c*) Dr. Herbert C. Preul.
(*d*) Theoretical; laboratory and field.
(*e*) Measurements for the development of practical methods for the analysis of the transport of pollutants in flow through an aquifer.
(*h*) **Travel of Pollutants Through an Aquifer,** *Proc. Purdue Industrial Waste Conf.*, May 1971.

031-07935-300-36

ESTIMATION OF STREAMFLOW CHARACTERISTICS USING AIRPHOTOS

(*b*) Partly supported by EPA.
(*c*) E. A. Joering and Dr. Herbert C. Preul.
(*d*) Theoretical, laboratory and field.
(*e*) Development of a procedure for estimating a flow duration curve and floods of selected frequency using airphotos.
(*h*) **A Set of Regime Equations for Indirectly Estimating Stream Flow Characteristics,** E. A. Joering, H. C. Preul, *Proc. 1st Intl. Cong. Water Resources*, Chicago, Sept. 1973; available from Intl. Water Resources Assoc., P. O. Box 5691, Milwaukee, Wis. 53211.

031-07936-250-00

VISCOELASTIC BOUNDARY HYDRAULICS

(*c*) Dr. Louis M. Laushey.
(*d*) Experimental and theoretical; Ph.D. dissertation.
(*e*) Waves are developed and measured on a layer of gelatin coating the bed of an open channel. The friction loss in the fluid and the dissipation within the gelatin are measured.
(*f*) Suspended.
(*h*) **Friction Loss Over Viscoelastic Coatings On Open Channels,** E. W. Lindeijer, Jr., L. M. Laushey, *XVth Cong., Intl. Assoc. Hydraulic Research*, Istanbul, Sept. 1973.

CLEMSON UNIVERSITY, Department of Chemical Engineering, Clemson, S.C. 29631. Professor C. E. Littlejohn, Department Head.

032-07942-250-00

INCREASE TURBULENT DISPERSION IN DILUTE HIGH POLYMER DRAG REDUCING OPEN CHANNEL FLOW

(*c*) J. P. Peterson, Graduate Student or W. F. Beckwith, Assoc. Professor.
(*d*) Experimental, theoretical, basic; Ph.D. thesis.
(*e*) Determine the effect of high molecular weight drag reducing additives on the turbulent dispersion coefficient. Tracer concentration profiles in the longitudinal direction were measured at two stations along the length of an open channel. Also, the characteristics of drag reduction were studied for both supercritical and subcritical flow.
(*f*) Completed.
(*g*) Drag reduction can be readily obtained in supercritical flow but difficult to obtain in subcritical flow, because of the difficulty of obtaining the necessary high onset shear stress of 0.11 lb_f/ft^2. Drag reduction results were analyzed with respect to von Karman's constant, k, which was shown to vary from 0.40 to 0.074 for water flow and 100 ppm AP30 flow, respectively. The longitudinal turbulent dispersion coefficient in two-dimensional drag reducing flows increased with increasing polymer concentrations at a given Reynolds number. A linear relationship between the dispersion coefficient and Reynolds number for each polymer concentration was determined.
(*h*) **Enhanced Dispersion in Drag Reducing Open Channel Flow,** J. P. Peterson, W. E. Castro, P. B. Zielinski, W. F. Beckwith, *J. Hydraul. Div., Proc. ASCE* **100,** HY6, pp. 773-785, June 1974.

COLORADO SCHOOL OF MINES, Basic Engineering Department, Golden, Colo. 80401. Professor R. R. Faddick.

033-08130-130-00

COARSE SLURRY VISCOMETER

(*b*) Colorado School of Mines Research Committee.
(*d*) Experimental; development.
(*e*) A "viscometer" is being developed to handle mineral slurries coarser than 65 Tyler mesh.
(*f*) Completed.
(*g*) Analagous Moody diagrams relating power consumption to suspend slurries versus Reynolds number of mixing were developed for sand and coal slurries.
(*h*) **Investigation of a Slurry Bench Test,** N. J. Lavingia, R. R. Faddick, *Hydrotransport* **3,** *BHRA-CSM Paper H2*, Golden, Colo., May 1974.
Mixing of Mineral Slurries, N. J. Lavingia, *M.Sc. Thesis*, Colo. School of Mines, Golden, Colo., 1973.

033-08131-130-70

RHEOLOGY OF MINERAL SLURRIES

(*b*) Commercial.
(*d*) Applied research.
(*e*) Rheological data are being measured for predicting headlosses for such slurries as bauxite, heavy mineral sand, phosphate, hematite, chalcopyrite, and ocean sediments.
(*g*) Most mineral slurries are yield pseudoplastic.
(*h*) **Flow Properties of Coal-Water Slurries,** R. R. Faddick, *Hydrotransport* **3,** *BHRA-CSM Paper H1*, Golden, Colo., May 1974.
Rheology of Non-Newtonian Slurries Using a Stormer Viscometer, V. S. Rao, *M.Sc. Thesis*, Colo. School of Mines, Golden, Colo., 1974.

033-08787-130-00

ECONOMICS OF SLURRY PIPELINING

(*b*) Colorado School of Mines Research Committee.
(*d*) Theoretical, experimental.
(*e*) A technique is presented for the economic selection of a slurry pipeline with the aid of a computer.
(*g*) The program has been verified with field data and is valid for both homogeneous and heterogeneous mineral slurries.
(*h*) **The Economic Selection of a Slurry Pipeline,** J. M. Link, N. J. Lavingia, R. R. Faddick, *Hydrotransport* **3,** *BHRA-CSM Paper K3*, Golden, Colo., May 1974.
The Economics of Pipeline Transportation of Mineral Commodities, N. J. Lavingia, *Ph.D. Thesis*, Colo. School of Mines, Golden, Colo. 1974.

033-08788-130-49

PNEUMATIC-HYDRAULIC MATERIAL TRANSPORT SYSTEM FOR RAPID EXCAVATION OF TUNNELS

(*b*) U. S. Department of Transportation.
(*d*) Theoretical.
(*e*) A combination pneumatic-hydraulic pipeline system was evaluated for muck haulage in rapid transit tunnels.
(*g*) The technical and economic feasibility of the system was evaluated by digital computer using field costs and data.
(*h*) **Pneumatic-Hydraulic Material Transport System for Rapid Excavation of Tunnels,** R. R. Faddick, J. W. Martin, *DOT-TST-75-17*, U. S. Dept. Trans., Aug. 1974.

COLORADO STATE UNIVERSITY, ENGINEERING RESEARCH CENTER, College of Engineering, Foothills Campus, Fort

Collins, Colo. 80521. Dr. D. B. Simons, Associate Dean, Engineering Research Center.

034-07001-810-05

SIMULATION OF HYDROLOGIC SYSTEMS

(*b*) Cooperatively with U.S. Dept. Agriculture.
(*c*) Dr. D. A. Woolhiser, Research Hydraulic Engineer.
(*d*) Theoretical and experimental; basic and applied.
(*e*) Develop procedures for numerically simulating the surface runoff hydrograph of small watersheds and objective techniques for transforming complex watersheds into simple combinations of overland flow planes and channels for numerical simulation.
(*g*) The time of occurrence T(t) of the largest flood exceedance in some time interval (O,t) has been described as a stochastic process. A stochastic model of n-day rainfall has been developed and progress has been made in regionalizing the parameters. An infiltration subroutine and a routine for calculating unsteady flow in a circular conduit have been added to a general kinematic cascade program for calculating surface runoff from small agricultural or urban watersheds.
(*h*) **Hydrologic and Watershed Modeling - State of the Art,** D. A. Woolhiser, *Trans. ASAE* **16**, pp. 553-559, 1973.
Large Material Models in Watershed Research, D. A. Woolhiser, E. F. Schulz, *Proc. IAHR Intl. Symp. on River Mechanics*, Bangkok, Thailand, 63-74, 1973.
Temporal and Spatial Variation of Parameters for the Distribution of n-day Precipitation, D. A. Woolhiser, E. Rovey, P. Todorovic, in *Floods and Droughts, Proc. Intl. Symp. in Hydrology*, Water Resources Publications, Fort Collins, Colo., pp. 605-616, 1973.

034-07247-800-00

WATER RESOURCES OPTIMIZATION

(*b*) Colorado State University, Agricultural Experiment Station.
(*c*) E. V. Richardson.
(*d*) Experimental, theoretical; applied research and development.
(*e*) To research and apply methods to optimization of the water resources of Colorado. Studies include methods of reducing water loss by seepage, evaporation or transportation; to improve efficiency of the distribution systems by consolidation of conveyance systems; application of linear and dynamic programming, and design of conveyance systems.
(*g*) Research on cohesive soils has shown that their erodibility is highly dependent on soil-water chemistry interaction. Field studies are underway to determine hydraulic and soil conditions for several stable channels and to relate these conditions to the laboratory studies. A mathematical programming optimization model was developed for planning multipurpose-multicomplex water resource systems. A three-dimensional, finite difference model was developed for simulating steady and unsteady, saturated and unsaturated flow in a stream aquifer system.
(*h*) **Diffusion and Dispersion in Open Channel Flow,** E. V. Richardson, A. C. Miller, *Hydraulics Div. J., ASCE* **100**, Jan. 1974.
Sediment Routing in Irrigation Canal Systems, K. Mahmood, *Irrigation and Drainage Div. J., ASCE*, Mar. 1974.
River Dispersion: A Skewed Distribution, G. V. Sabol, *Ph.D. Dissertation*, Colo. State Univ., May 1974.
Water Resources Decision Evaluation Model, D. Laura, *Ph.D. Dissertation*, Colo. State Univ., Aug. 1974.
Numerical Model of Flow in a Stream-Aquifer System, Colo. State Univ., Dec. 1974.

034-07269-820-00

GROUNDWATER RESERVOIR MANAGEMENT

(*b*) Colorado Experiment Station.
(*c*) R. A. Longenbaugh, Asst. Professor.
(*d*) Field studies, theoretical and applied.
(*e*) Directed towards better management of Colorado's groundwater resources. Results from this research have also been applied to world-wide problems and are currently extensively used in the administration of Colorado's water resources. Mathematical models for predicting groundwater movement and quality changes have been developed. Demonstration projects for artificial recharge are currently underway. Linear and dynamic programming techniques are currently being evaluated to determine optimal operational policies for conjunctive use of ground and surface water. Selected observation wells are measured throughout the state and groundwater levels reported annually.
(*f*) Active with anticipated re-direction of goals as new problems are defined.
(*g*) See (h).
(*h*) **A Digital Model of a Stream-Aquifer System on the South Platte River Near Sterling, Colorado,** A. F. Olson, *MS Thesis*, Colo. State Univ., Fort Collins, Colo., June 1973, 71 pp.
Galerkin Simulation of Hydrodynamic Dispersion, A. Prakash, *Ph.D. Dissertation*, Colo. State Univ., Fort Collins, Colo., Apr. 1974, 182 pp.
Optimal Conjunctive Use of Surface and Groundwater, South Platte Ditch Company Near Sterling, Colorado, E. Rios Reategui, *MS Thesis*, Colo. State Univ., Fort Collins, Colo., Fall 1974, 91 pp.
Analytical Model of Stream-Aquifer System with Pumping and Recharge, D. B. McWhorter, D. K. Sunada, A. Prakash, W. W. Burt, *Completion Rept.*, State Engineer's Office, Oct. 1, 1972.
Finite Element Method for the Hydrodynamic Dispersion Equation with Mixed Partial Derivatives, M. Nalluswami, R. A. Longenbaugh, *Water Resour. Res.* **8**, 5, Oct. 1972, pp. 1247-1250.

034-07943-220-05

SEDIMENT DETACHMENT, TRANSPORT AND DEPOSITION PROCESSES

(*b*) Cooperatively with U.S. Dept. of Agriculture.
(*c*) Dr. D. A. Woolhiser, Research Hydraulic Engineer.
(*d*) Theoretical and experimental; basic and applied.
(*e*) Determine the probability distribution of the instantaneous boundary shear stress and Reynolds stress near a smooth wall for varying open channel flows and to develop a stochastic model of the sediment detachment and entrainment processes based on turbulent structure in open channel flow.
(*f*) Completed.
(*g*) Analysis of measurements of turbulent velocities and instantaneous boundary shear stress in an open channel have been completed. The turbulent fluctuations of boundary shear stress were found to decrease with increasing Reynolds numbers. The probability density function of the instantaneous boundary shear stress is a non-Gaussian, positively skewed, Reynolds number dependent distribution. Spectral analysis showed that the boundary shear stress is a low frequency process with the high frequency energy content increasing with increasing Reynolds number. The spectral Reynolds number shift was found to be linear with the local mean boundary shear stress.
Decomposition of the instantaneous boundary shear stress process into a counting exceedance process revealed that for high threshold levels the shear stress exceedance in the interval (0,t) can be described by a homogenous Poisson process. The mean period between shear stress exceedances is of the same magnitude as the interval between events in the "busting process."
A time-space correlation analysis showed a line of maximum correlation between the boundary shear stress and the longitudinal velocity fluctuations outside of the viscous sublayer. Large scale disturbances entered the viscous sublayer along a line inclined upstream at 20° from the wall.

(*h*) **Stochastic Structure of the Turbulent Boundary Shear Stress,** P. H. Blinco, K. Mahmood, D. B. Simons, *Proc. XVth Cong. IAHR*, Istanbul, 1973.
Measurement of Instantaneous Boundary Shear Stress, P. H. Blinco, D. B. Simons, *Proc. Hydraulic Div. Specialty Conf., ASCE*, Bozeman, Mont., 1973.
Turbulent Measurements Near a Wall with Split-Film Sensor, P. H. Blinco, V. A. Sandborn, *Proc. 3rd Biennial Symp. Turbulence in Liquids*, Rolla, Mo., Sept. 1973.
Characteristics of Turbulent Boundary Shear Stress, P. H. Blinco, D. B. Simons, *J. Engrg. Mech. Div., ASCE* **100** EM2, Apr. 1974.

034-08801-300-15

A GEOMORPHIC STUDY OF POOLS 24, 25 AND 26 IN THE UPPER MISSISSIPPI AND LOWER ILLINOIS RIVERS

(*b*) U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss.
(*c*) D. B. Simons.
(*d*) Applied research.
(*e*) A study of past and present geomorphic features of that reach of the Upper Mississippi River which has been transformed into Pools 24, 25 and 26 and the lower reach of the Illinois River which has been transformed into Alton Pool by Lock and Dam 26. Objectives are to identify the primary components of the processes by which the geomorphology has been changing and to assess future geomorphic changes which will occur from past, present and planned future developments in the study reach.

034-08802-300-34

A STUDY OF THE GEOMORPHOLOGY OF THE UPPER MISSISSIPPI RIVER

(*b*) U. S. Department of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
(*c*) D. B. Simons.
(*d*) Theoretical with field investigations, and applied research.
(*e*) Information is being assimilated on the past and present geomorphic features of the Upper Mississippi River between the confluence with the Illinois River and St. Paul, Minnesota. The principal components of the geomorphic processes are being identified along with those changes induced by man's activity. Future geomorphic changes which will occur from past, present and planned future development and alternatives thereto are to be predicted.

034-08803-300-15

GEOMORPHOLOGY OF THE MIDDLE MISSISSIPPI RIVER

(*b*) U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss.
(*c*) D. B. Simons.
(*d*) Experimental with field investigation, applied research.
(*e*) A study of the geomorphological aspect of reducing the river widths to obtain a navigation channel and the physical impacts of river contraction works on the side channel along the Middle Mississippi River between St. Louis, Missouri and Cairo, Illinois.
(*f*) Completed.
(*g*) See (h).
(*h*) **Geomorphology of the Middle Mississippi River,** D. B. Simons, S. A. Schumm, M. A. Stevens, *CER73-74DBS-SAS-MAS9*, Colo. State Univ., Fort Collins, Colo., Jan. 1974.
Man-Induced Changes of the Middle Mississippi River, M. A. Stevens, D. B. Simons, S. A. Schumm, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **101**, WW2, May 1975.

034-08804-220-06

DEVELOPMENT OF MODELS FOR PREDICTING SEDIMENT YIELD FROM SMALL WATERSHEDS

(*b*) U. S. Dept. of Agriculture, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Ariz.
(*c*) D. B. Simons.
(*d*) Theoretical with field investigations; basic and applied research.
(*e*) Development of prediction models for estimating sediment yield from a broad spectrum of source areas and watersheds. The prediction models have been tested on study areas with the Coconino National Forest in Arizona and will be tested in other areas.
(*g*) See (h).
(*h*) **Development of Models for Predicting Sediment Yield From Small Watersheds,** D. B. Simons, R. M. Li, M. A. Stevens, Draft Report, *CER74-75DBS-RML-MAS23*, Civil Engrg. Dept., Colo. State Univ., Fort Collins, Colo., Dec. 1974.
Review of Literature, Cooperative Study on Development of Models for Predicting Sediment Yield From Small Watersheds, R. M. Li, D. B. Simons, M. S. Stevens, Colo. State Univ. Rept., 1973.
Mechanics of Soil Erosion by Overland Flow, R. M. Li, H. W. Shen, D. B. Simons, presented *15th Congress Intl. Assoc. Hydraul. Res.*, Istanbul, Turkey, *Proc. Paper A54*, Sept. 1973.
Nonlinear Kinematic Wave Approximation for Water Routing, R. M. Li, D. B. Simons, M. A. Stevens, *Water Resour. Res.* **11**, 2, Apr. 1975, 245-252.
Stream Morphology in Small Watersheds, R. M. Li, D. B. Simons, M. S. Stevens, presented *55th Ann. Mtg. Amer. Geophys. Union*, Washington, D. C., Apr. 1974.
Equations for the Physical Process Simulation Model, D. B. Simons, M. A. Stevens, Colo. State Univ. Rept., Mar. 1973.

034-08805-810-33

ANALYSIS OF COLORADO PRECIPITATION

(*b*) OWRT.
(*c*) Stephen K. Cox, Dept. of Atmospheric Science.
(*d*) Experimental, basic research; Master's thesis.
(*e*) Provide basic statistics on the amount and frequency of precipitation events in Colorado. Both long-term precipitation records and more detailed documentation on individual precipitation events over the last twenty years are being analyzed.

034-08806-870-33

EVALUATION AND IMPLEMENTATION OF URBAN DRAINAGE AND FLOOD CONTROL PROJECTS

(*b*) OWRT.
(*c*) Neil S. Grigg.
(*d*) Applied research.
(*e*) Urban drainage and flood control (UDFC) systems provide a service to urban areas with three basic components: flood control, convenience drainage and environmental sanitation. This service is one of many provided by local government and must compete for public funding with other more visible programs such as education, transportation and public safety. The evaluation problem for UDFC arises when the merit of individual UDFC systems must be determined, when competing UDFC projects must be ranked, when optimal investment timing is sought and when the incidence of UDFC benefits and costs must be known. The results of all of these evaluations affect the funding of the UDFC sector, in competition with other public programs.
(*f*) Completed.
(*g*) This was Phase I of a two-phase research project intended to develop a methodology for analyzing benefits and costs of multijurisdictional urban drainage projects. An interdisciplinary team was assembled consisting of university faculty, consulting engineers, and an attorney specializing in water resources problems. The literature was reviewed and the initial work was concentrated on the development of a state-of-the-art methodology for evaluating minor and major urban drainage projects according to current knowledge of the benefits of these projects. The result of this has been a seminar to a user group in Denver as well

as a final report for wide dissemination to be completed June 30. Co-sponsor of the research project was the Urban Drainage District, Denver, Colorado, and the Technical Advisory Committee of the District served as a project advisory committee for the research project.

(*h*) **Remarks on Criteria for Selection of Urban Stormwater and Flood Control Projects,** N. S. Grigg, *Pacific Public Works Conf.*, Honolulu, Apr. 1974.
Evaluating and Implementing Urban Drainage and Flood Control Projects, N. S. Grigg, *Flood Hazard News*, Aug. 1974, publication of the Urban Drainage and Flood Control District, Denver, Colo.
Criteria for Evaluation of Urban Drainage and Flood Control Projects, N. S. Grigg, presented *ASCE Natl. Environmental Mtg.*, Kansas City, Mo., Oct. 1974.
State of the Art of Estimating Flood Damage in Urban Areas, N. S. Grigg, O. J. Helweg, *Water Resources Bull.*, Amer. Water Res. Assoc., Feb. 1975 (tentative).
Evaluation and Implementation of Urban Drainage Projects, N. S. Grigg, *J. Urban Planning and Development Div., ASCE* **101,** UP1, May 1975.

034-08807-870-33

EVALUATION OF BENEFITS AND COSTS OF MULTI-JURISDICTIONAL URBAN DRAINAGE PROJECTS

(*b*) OWRT.
(*c*) Neil S. Grigg.
(*d*) Applied research.
(*e*) In Phase II of this research it is proposed to extend the results of Phase I with the objective of incorporating socio-economic planning techniques and evaluation methods into a direct evaluation methodology developed during Phase I. In Phase I, currently underway efforts are directed toward finding valid methods for estimating urban property damage from flooding, toward the enumeration of intangible and indirect costs and benefits and toward the development of practical techniques for estimating property damage from the data base normally available in urban areas. In Phase II additional more sophisticated methodology for evaluation of projects will incorporate recent results of OWRT studies on socio-economic and cultural benefits. Since the multijurisdictional urban drainage problem is directly associated with urban land use problems the research is to be keyed to community land use and associated goals with the resulting methodology being first usable, and at the same time, sophisticated in its application of community goal seeking and evaluation methodology. The project will continue to use local involvement by the Urban Drainage and Flood Control District in Denver as a key factor to ensure the relevance of the research results.
(*g*) Final results will consist of a report containing comprehensive methodologies for evaluating urban drainage and flood control projects, major and minor; methods to measure benefits of such projects; and model legislation to provide statutory basis for such measurements.

034-08808-870-33

SALT BALANCE MANAGEMENT IN THE LOWER SAN LUIS REY RIVER BASIN

(*b*) OWRT.
(*c*) John W. Labadie; George L. Smith.
(*d*) Applied research for operational development. Doctoral thesis.
(*e*) Develop a flexible mathematical model simulating the dynamics of salt balance in the Upper San Luis Rey River Basin, located in Southern California. Such a model is critically needed for development of measures for controlling degradation of the groundwater basin from salt accumulation due to irrigation return flow and uncontrolled storm runoff, until demineralization becomes economically feasible. The effects of various control measures, including those proposed by the Joint Administration Committee of the Santa Margarita and San Luis Rey Watershed Planning Agencies, can be projected by the model, as well as possible consequences of pending litigation before the Federal Power Commission concerning upstream diversion of San Luis Rey water to areas outside the watershed. The model should provide a means of evaluating various management alternatives leading to maximization of the beneficial use of the spatial and temporal quantity and quality of the groundwater resource. In particular, the effects of importation of Colorado River Water; upstream diversion of San Luis Rey River flow, effects of proposed treatment facilities and drainage systems, constraints on quantity and quality of flow leaving the study area, and hydrologic stresses from projected land use and population growth, will be evaluated.
(*g*) Current effort has involved adaption of recent USGS groundwater quantity-quality models for the study area in such a way that they are conducive to innovative management studies.

034-08809-870-33

IMPLEMENTATION OF OPTIMAL COMPUTER CONTROL FOR COMBINED SEWER SYSTEMS

(*b*) OWRT.
(*c*) Neil S. Grigg.
(*d*) Applied research.
(*e*) Development and implementation of automated control strategy for combined sewer systems by considering a specific case in which the following problem areas will be investigated: (1) The development of a viable on-line/off-line control scheme; (2) the development from existing models of the best practical models for use in implementing the Metropolitan Water Intelligence System according to the scheme adopted in (1); (3) development of a feedback control technique that will utilize the best rainfall projection models available; (4) determination of economical and acceptable hardware configurations based on the findings of (1), (2) and (3); and (5) the development and implementation based on (1)-(4) above. The specific case is the "San Francisco Master Plan for Wastewater Management." A working arrangement with San Francisco officials is already established and holds promise for successful cooperation in the next phases of their work.

034-08810-870-54

OPTIMAL CONTROL OF LARGE-SCALE COMBINED SEWER SYSTEMS

(*b*) National Science Foundation.
(*c*) Neil S. Grigg; John W. Labadie.
(*d*) Applied research for operational development; Doctoral thesis.
(*e*) The pollution of receiving waters by overflows from combined sewers is a national problem of serious concern. A recent viable solution strategy for the problem involves the development of automatic control systems as an alternative to more expensive sewer separation or large-scale treatment projects. Development of the control logic is a difficult problem from the standpoint of both optimal control theory and urban hydrology. The large-scale problem is therefore decomposed into several Subbasin Problems, with a Master Problem tying them together. Finite or infinite-dimensional optimization can be applied to the Subbasin Problems, and linear or dynamic programming is recommended for the Master Problem. A feedback control strategy is suggested where the Subbasin Problems can be solved either on-line or off-line, depending on the complexity of the sewer transport models utilized. The most challenging remaining problems include incorporating realistic sewer routing into the optimization, accurate storm prediction, and on-line computer hardware specification.
(*g*) Control problem development and system decomposition have essentially been completed. The subbasin problems and the overall master problem have been defined, formulated and tested. Current effort is oriented toward proper incorporation of uncertainty of storm prediction in the control algorithms and implementation feasibility studies.

(*h*) **Minimization of Combined Sewer Overflows by Large-Scale Mathematical Programming,** J. W. Labadie, N. S. Grigg, *J. Computers and Operations Research* **1**, Dec. 1974, 26 pages.
Real Time Control of a Large-Scale Combined Sewer System, B. H. Bradford, *Ph.D. Dissertation*, Colo. State Univ., Dept. Civil Engrg., Aug. 1974, 167 pages.

034-08811-870-33

METROPOLITAN WATER INTELLIGENCE SYSTEMS – PHASE III FINAL REPORT

(*b*) OWRT.
(*c*) Neil S. Grigg.
(*d*) Applied research.
(*e*) Development of control strategy for automated combined sewer systems; interrelate computer and control equipment system design with the control strategy adopted; identify and describe the socio-political and economic factors to be considered in implementation. This report mainly describes factors associated with the three objectives above. It also attempts to interrelate results from Phase I and II as well.
(*f*) Completed.
(*g*) The results of the three Phases of the Colorado State University project "Metropolitan Water Intelligence Systems" (MWIS) are reported. The special type of MWIS considered is the fully automated control system for combined sewer systems. The report principally contains technical data on the solution of the control strategy problem and on optimization techniques for developing control logic. The socio-political problems associated with implementing a MWIS are discussed as well as the problems facing local decision makers who must comply with shifting standards under heavy time, technological, financial and political constraints.
(*h*) **Automated Control in Large-Scale Metropolitan Water Intelligence Systems,** J. W. Labadie, N. S. Grigg, presented *43rd Natl. Mtg. of ORSA*, Milwaukee, Wis., May 9-11, 1973.
Planning and Wastewater Management of a Combined Sewer System in San Francisco, N. S. Grigg, *Tech. Rept. No. 10*, *Metropolitan Water Intelligence Systems Project*, Colo. State Univ., June 1973.
Minimization of Combined Sewer Overflows by Large-Scale Mathematical Programming, J. W. Labadie, N. S. Grigg, *Intl. Symp. on Applications of Computers and Operations Research to Problems of World Concern*, Aug. 20-21, 1973, Washington, D. C.
Urban Water Management and Control Systems, N. S. Grigg, presented *1974 ASCE Hydraul. Div. Spec. Conf.*, Knoxville, Tenn.
Automatic Control of Large-Scale Storm and Combined Sewer Systems, J. W. Labadie, N. S. Grigg, B. H. Bradford, *J. Environmental Engrg. Div., ASCE* **101**, EE-1, Feb. 1975.
Automation and Control of Urban Water Systems, N. S. Grigg, J. W. Labadie, *Water and Wastes Engrg.*, in press.
Metropolitan Water Intelligence Systems, A. S. Grigg, J. W. Labadie, H. G. Wenzel, *Completion Report, Phase III*, Colo. State Univ., June 1974.

UNIVERSITY OF COLORADO, Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, Colo. 80302. Professor Carl Kisslinger, Institute Director.

035-08812-480-54

DYNAMICS OF ATMOSPHERIC FLOWS

(*b*) National Science Foundation (in part).
(*c*) George Chimonas, Assoc. Director (Atmos. Sci.), CIRES.
(*d*) Basic theoretical research.
(*e*) This program investigates the micro and meso scale dynamics of atmospheric flows with particular emphasis on the role played by waves. The continuing research has examined the stability of shear flows (with and without boundaries), the modifications produced by water substance and the interaction between waves/turbulence/mean flows. Future developments are expected to include applications to the dynamic development of the planetary boundary layer, and the further investigation of waves generation by meso-scale systems. The program is active and expanding.

COLUMBIA UNIVERSITY, Department of Chemical Engineering and Applied Chemistry, New York, N. Y. 10027. Charles F. Bonilla, Department Chairman.

036-08813-010-52

VELOCITY AND TURBULENCE DISTRIBUTION IN BOUNDARY LAYERS IN LOW TURBULENCE CHANNEL FLOW

(*b*) Energy Research and Development Administration.
(*d*) Experimental.
(*e*) Velocity and turbulence measurements were made in the boundary layer of a rectangular channel at low Reynolds numbers and low dimensionless wall-distances y^+. To increase the accuracy of the velocity and wall-distance measurements, the channel was designed one inch thick and an oil was used as the recirculating fluid.
(*g*) The results clearly confirm that the simple laminar sublayer theory does not hold, even at these low Reynolds numbers, as turbulence penetrates completely to the wall on occasion. It was found possible to either confirm or disprove Nijsing's boundary layer instability model.
(*h*) **Velocity and Turbulence Distribution in Boundary Layers in Low Turbulence Channel Flow,** A. J. Modi, J. W. Chung, C. F. Bonilla, *AEC Report C00-3027-1*, presented *Symp. on Fundamental Res. in Fluid Mechanics, Part II*, Amer. Inst. of Chem. Engrs. 67th Ann. Mtg., Washington, D. C., Dec. 1974.

COLUMBIA UNIVERSITY, Lamont-Doherty Geological Observatory (See Lamont-Doherty Geological Observatory).

UNIVERSITY OF CONNECTICUT, Marine Sciences Institute, Groton, Conn. 06340. Peter Dehlinger, Institute Director.

037-08004-450-54

COASTAL UPWELLING

(*b*) National Science Foundation, Office for the Intl. Decade of Ocean Exploration.
(*c*) Asst. Prof. R. W. Garvine.
(*d*) Theoretical and field investigations; basic research.
(*e*) Theoretical investigations have been conducted for the steady, wind-driven coastal upwelling of homogeneous water both with and without the effects of bathymetry. A field program is underway that will involve tracking of surface drogues in the Ekman layer during summer upwelling off the Oregon coast.
(*h*) **The Effect of Bathymetry On the Coastal Upwelling of Homogeneous water,** R. W. Garvine, *J. Phys. Oceanog.* **3**, 47-56, 1973.
Ocean Interiors and Coastal Upwelling Models, R. W. Garvine, *J. Phys. Oceanog.* **4**, 121-125, 1974.

037-08005-400-44

RIVER DISCHARGE INTO LONG ISLAND SOUND

(*b*) National Oceanic and Atmospheric Administration, Office of Sea Grant Programs.
(*c*) Asst. Prof. R. W. Garvine.

(*d*) Field investigations; applied research.
(*e*) Field investigations of the Connecticut River discharge plume have been initiated in conjunction with a larger program to determine a heavy metal budget for eastern Long Island Sound. Salinity, temperature and water surface color in the discharge area are measured using boats and aircraft. Drogues will be tracked to determine residence times for freshened surface water in the Sound.
(*h*) **Physical Features of the Connecticut River Outflow During High Discharge,** R. W. Garvine, *J. Geophys. Res.*, **79**, 831-846, 1974.

037-08006-400-33

AN INVESTIGATION OF TURBIDITY IN ESTUARINE WATERS

(*b*) Office of Water Res. Research, Dept. of the Interior.
(*c*) Asst. Professor W. F. Bohlen.
(*d*) Field investigation; basic research.
(*e*) This investigation is examining the relationship between total turbidity and its component parts. These data are being used to develop methods and instrumentation capable of providing long term *in situ* turbidity data in rivers and estuaries.
(*h*) **Turbidity Measurements in Estuaries,** W. F. Bohlen, Abstract, *EOS Trans. Amer. Geophys. Un.* **53**, 4, 1972.

037-08007-220-44

SUSPENDED MATERIAL TRANSPORT IN LONG ISLAND SOUND

(*b*) National Oceanic and Atmospheric Administration, Office of Sea Grant Programs; U. S. Army Corps of Engineers; U. S. Navy Underwater Systems Center..
(*c*) Asst. Professor W. F. Bohlen.
(*d*) Field investigation; applied reasearch.
(*e*) A knowledge of the relationships governing the concentrations of suspended materials is an essential element of a larger program seeking to establish a heavy metal budget applicable to eastern Long Island Sound. During the first year an extensive field investigation will examine the relationship between suspended load concentrations and the total velocity field in the eastern Sound. Two fixed buoy arrays containing temperature, salinity, velocity and turbidity sensors will be used to complement the monthly turbidity data being obtained at a network of twelve stations. These data will be incorporated directly into the calculation of the heavy metal budget and into the development of quantitative predictive techniques.
(*h*) **Suspended Material Concentrations in Eastern Long Island Sound,** (Abstract), W. F. Bohlen, *EOS Trans. Amer. Geophys. Un.* **1**, 54 (4):259, 1973.
Continuous Monitoring Systems in Long Island Sound: Description and Evaluation, W. F. Bohlen, *Proc. IEEE Intl. Conf. on Engrg. in the Ocean Environment*, Halifax, Nova Scotia, **2**, 67-69, 1974.
The Effects of Storms On Suspended Material Concentrations In Eastern Long Island Sound, (Abstract), W. F. Bohlen, M. M. Smith, *EOS Trans. Amer. Geophys. Un.*, **55**, (4):280, 1974.
For the following reports contact author for copy:
An Investigation of Suspended Material Transport in Eastern Long Island Sound, Univ. of Connecticut Marine Sci. Institute *Ann. Rept. to Office of Sea Grant Programs*, NOAA, Rockville, Md., Appendix E, 29 p.
A Water Quality Survey of the Sewage Treatment Plant Discharge Areas Adjoining Stonington, Connecticut: The Mystic River Estuary, W. F. Bohlen, prepared for the Town of Stonington, Conn., 37 p., 1973.
Oceanographic Factors Relating to the Disposal of Dredged Materials in Long Island Sound. Physical and Chemical Characteristics of the Waters Adjacent to the New Haven Dredge Spoils Disposal Site: Data report 1972-1973, W. F. Bohlen, J. M. Tramontano, prepared for the New England Div., U. S. Army Corps Eng., 44 pages and App., 1974.
Oceanographic Factors Relating to the Disposal of Dredged Materials in Long Island Sound. Physical and Chemical Characteristics of the Waters Adjacent to the New Haven Dredge Spoils Disposal Site: Data report 1973-1974, W. F. Bohlen, J. M. Tramontano, prepared for the New England Div., U. S. Army Corps Eng., 34 pages and App., 1974.
An Investigation of Suspended Material Concentrations in Eastern Long Island Sound, W. F. Bohlen, Univ. of Conn. Marine Sci. Inst. *Final Rept. to Office of Sea Grant Programs*, NOAA, Rockville, Md., pp. 100-131, 1974.
A Photographic Survey of the Bottom Conditions Characteristic of the New Haven Dredge Spoils Disposal Site, 1972-1974, W. F. Bohlen, A. J. Nalwalk, H. R. Robinson, prepared for the New England Div., U. S. Army Corps Eng., 33 pages, 1974.

037-08008-440-87

WINTER CIRCULATION IN LAKE ONTARIO

(*b*) Canada Center for Inland Waters, Burlington, Ontario.
(*c*) Asst. Prof. D. F. Paskausky.
(*d*) Theoretical investigation; basic research.
(*e*) A prognostic, barotropic, numerical circulation model for Lake Ontario has been developed for use with data from IFYGL.
(*f*) Continuing with University of Connecticut support.
(*g*) Lake Ontario set-up during a storm being calculated.
(*h*) **Two-Dimensional Numerical Prediction of Storm Surge in Lake Erie,** D. F. Paskausky, D. L. Murphy, *Proc. 16th Conf. Great Lakes Res.*, Intl. Assoc. Great Lakes Res., pp. 808-817, 1973.
Two-Dimensional Numerical Prediction of Storm Surge in Lake Erie, D. F. Paskausky. Appendix 2G PSAR Perry Nuclear Power Plant, Cleveland Electric Illuminating Co., 43 pp., Jan. 1973 (contact author for copy).

037-08009-490-22

PHYSICAL OCEANOGRAPHY OF BLOCK ISLAND SOUND

(*b*) U.S. Naval Underwater Systems Center, New London, Conn.
(*c*) Assoc. Professor A. J. Nalwalk.
(*d*) Field investigation; basic research.
(*e*) Temperature, salinity, sound velocity, currents and plankton are being monitored at four stations in Block Island Sound near the BIFI range.
(*g*) Reports available from NUSC.
(*h*) **Final Report of Oceanographic Measurements Along the Block Island-Fishers Island (BIFI) Range in Block Island Sound from July 1970 to May 1972,** D. F. Paskausky, 97 pp.
Grain Size Analysis of Sediments Within the BIFI Corridor, Block Island Sound, Rhode Island-New York, A. J. Nalwalk, D. F. Paskausky, H. G. Robinson, J. Daubenspeck, Rept. to Ordnance Research Lab., Dec. 1971.
Final Report of Oceanographic Studies Along the Block Island-Fishers Island Sound (BIFI) Range in Block Island-Sound from June 1972 to September 1972, A. J. Nalwalk, D. F. Paskausky, D. L. Murphy, H. G. Robinson, C. Y. Tsao, 77 pp., 1974.
Final Report of Oceanographic Studies Along the Block Island-Fishers Island (BIFI) Range in Block Island Sound from September 1972 to January 1974, A. J. Nalwalk, D. F. Paskausky, D. L. Murphy, H. G. Robinson, W. S. Stevens, 77 pp., 1974.

037-08671-450-22

CIRCULATION STUDIES OF VARIOUS BODIES OF WATER

(*b*) U. S. Naval Underwater Systems Center, New London, Conn., National Oceanic and Atmospheric Administration, Office of Sea Grant Programs; U. S. Army Corps of Engineers, Waltham, Mass.
(*c*) Asst. Professor D. F. Paskausky.
(*d*) Field investigation; basic research.

(*e*) Water circulation and model studies of certain areas that are of immediate concern to the environment and man.

(*h*) **Circulation and Energy Balance in Long Island Sound,** D. F. Paskausky, *Proc. Conf. Energy, Environment and Planning the Long Island Sound Region*, M. D. Goldberg, ed., held at Brookhaven Natl. Lab., NTIS No. BNL 50355, pp. 79-84, Feb. 1973.

Helicopter Launching of Surface and Sea-Bed Drifters, D. F. Paskausky, *Geophysical Research Letters* (*AGU*) **1,** 1, pp. 55-57, May 1974.

A Pseudo-Baroclinic Wind-Driven Circulation Model of the Gulf of Mexico, D. F. Paskausky, R. O. Reid, *J. Physical Oceanography*, in press, 1974.

A Determination of Heavy Metal Wastes in Long Island Sound, P. Dehlinger, W. F. Fitzgerald, S. Y. Feng, D. F. Paskausky, R. W. Garvine, W. F. Bohlen, *Ann. Rept. to Office of Sea Grant Programs*, NOAA, June 1973.

New Haven Dump Site Seabed and Surface Drifter Study, A. J. Nalwalk, D. F. Paskausky, W. F. Bohlen, D. F. Murphy, 16 pp., Feb. 1974.

Circulation in Long Island Sound Related to the New Haven Dump Site for Dredged Materials, D. F. Paskausky, A. J. Nalwalk, D. L. Murphy. Report to U. S. Army Corps of Engineers, Waltham, Mass., 25 pp., June 1974.

Baroclinic, Open Boundary Labrador Current Prediction Model, R. Kollmeyer, D. F. Paskausky, *EOS Trans. Amer. Geophys. Un.*, p. 1135, Dec. 1974.

UNIVERSITY OF CONNECTICUT, School of Engineering, Storrs, Conn. 06268. Professor C. J. Posey. (Summer address: Rocky Mountain Hydraulic Laboratory, Allenspark, Colo. 80510.)

038-05489-370-61

BOUND-ROCK EROSION PROTECTION FOR HIGHWAY DRAINAGE DITCHES

(*b*) Inst. of Water Resources; State Highway Department.

(*d*) Experimental; applied.

(*e*) Develop application of scientific erosion-protection method to highway ditches. Experiments will provide necessary design data and develop construction methods for low-cost installations.

(*f*) Trial installation on Route I-91 under continuing observation; others being planned.

(*g*) Trial installation on Route I-91 performing satisfactorily; standard specifications being prepared.

(*h*) **High Speed Ground Transportation Brings New Drainage Problems,** C. J. Posey, *High Speed Ground Transportation J.* **8,** 1, pp. 165-175.

038-05769-220-61

FILTER EROSION PROTECTION

(*b*) Water Resources Institute.

(*d*) Basic research; experimental.

(*e*) To determine whether finest-grained non-cohesive and/or cohesive materials can be protected by Terzaghi-Vicksburg inverted filter.

(*g*) If undermining of erosion protection by leaching out of material from underneath is to be avoided, the layers must meet the Terzaghi-Vicksburg inverted filter specifications. Rapidity of failure is proportional to degree of departure from the specifications. Filter layer that will protect D_{50} = 0.045 mm will protect any finer non-soluble material.

(*h*) **Erosion Control: Stability of Rock Sausages,** C. J. Posey, *Univ. of Conn. Inst. of Water Resources Rept. 19*, Nov. 1973, 15 pages.

Erosion-Proofing Drainage Channels, C. J. Posey, *J. Soil and Water Conservation* **28,** 2, 1973, pp. 93-95.

038-09009-220-00

TESTS OF SCOUR PROTECTION FOR BRIDGE PIERS

(*d*) Basic experimental.

(*e*) To see if reverse filter layers placed around bridge piers could prevent localized scour of non-cohesive bed material. Round and diamond-shaped piers were tested in a flume two meters wide, using simulated floods.

(*f*) Completed.

(*g*) To explore the method of limiting the depth of scour by surrounding the pier with protective material, model tests were made covering a range of constriction percentages, depths of flow, and Froude numbers, using both round and elongated piers. After determining the extent of the scour hole formed during the passage of a simulated flood, the protection afforded by a layer of protective material was tested with a repetition of the same flood. If the layer was large enough to resist being moved and had a grain-size distribution capable of preventing leaching, no scour hole formed. A special test showed protection remaining intact despite stream bed degradation.

(*h*) **Tests of Scour Protection for Bridge Piers,** C. J. Posey, *J. Hydraulics Division, ASCE* **100,** HY12, *Proc. Paper 11017*, Dec. 1974, pp. 1773-1783.

038-09010-220-00

ECONOMICAL EROSION PROOFING OF SUPERCRITICAL FLOW SECTIONS

(*c*) Dennis Morrow, Engrg. Research Center, A-318, Fort Collins, Colo. 80523.

(*d*) Applied experimental research, Master's thesis.

(*e*) Develop economical drop structure using rock sausages.

(*f*) Completed.

(*g*) By use of inverted filter base, crest with side constrictions, and sufficiently long rock sausages, structure can have trapezoidal section throughout. Possible ranges of height of drop and length of sausages, as determined by the model tests, are given in the thesis.

038-09011-450-00

MATHEMATICAL MODEL OF TIDAL MOTION IN LONG ISLAND SOUND

(*b*) University of Connecticut Research Foundation.

(*c*) Dr. J. D. Lin, Civil Engineering Department.

(*d*) Analytical and computational; basic research for Master's and Doctoral theses.

(*e*) Mathematical models both in one and two spatial dimensions are constructed for numerical experimentations of tide-related dynamical motions in Long Island Sound. The two-dimensional model may also be used to study unsteady, forced motion in a subregion in the Sound.

(*g*) The one-dimensional tidal computation is completed. By matching the tidal amplitude and phase angle between the computed results and the tidal records along the shores, useful information concerning the friction has been obtained. The refinement and numerical experimentations are being carried out for the two-dimensional model.

(*h*) **Tidal Motion in Long Island Sound,** J. D. Lin, J. Skridulis, *6th Ann. Long Island Sound Conf.*, N. Y. Ocean Science Lab., Montauk, N. Y., Dec. 1973.

Tidal Computations for Long Island Sound, J. D. Lin, J. Skridulis, *EOS, Trans. Amer. Geophys. Union* **56,** 2, Feb. 1975 (abstract).

038-09012-870-61

SPREADING OF OIL SLICKS IN A WIND-WAVE CHANNEL

(*b*) Water Resources Institute.

(*c*) Dr. J. D. Lin, Civil Engineering Department; Dr. G. S. Campbell, Mechanical Engineering Department.

(*d*) Experimental, basic research for M.S. and Ph.D. theses.

(*e*) Experimental study of oil spreading in a laboratory wind-wave channel to determine the effect of wind and waves on the convection and dispersion of oil films on the surface of water.

CORNELL UNIVERSITY, Department of Environmental Engineering, School of Civil and Environmental Engineering, Ithaca, N. Y. 14850. Daniel P. Loucks, Department Chairman.

039-08672-310-33

FLOOD PLAIN MANAGEMENT

(*b*) Office of Water Research and Technology, U. S. Dept. of the Interior.
(*d*) Theoretical applied research.
(*e*) Development of optimization models for analyzing structural and nonstructural flood control measures on flood plains.

039-08673-310-33

HYDROLOGICAL ASPECTS OF FLOOD MANAGEMENT IN THE CHEMUNG RIVER BASIN

(*b*) Office of Water Research and Technology, U. S. Dept. of the Interior.
(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and applied research.
(*e*) Analyze the watershed response characteristics of the Chemung Basin resulting from heavy precipitation.

039-08674-810-54

THE CALCULATION OF REGIONAL EVAPOTRANSPIRATION BY MEANS OF STANDARD METEOROLOGICAL DATA

(*b*) National Science Foundation.
(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and applied research.
(*e*) The investigation deals with the problem of the applicability of recently developed similarity schemes for the parameterization of the atmospheric boundary-layer under adiabatic conditions to the determination of surface vapor flux by means of synoptic meteorological data, which are published regularly or otherwise easily available.
(*h*) **Computing Evapotranspiration by Geostrophic Drag Concept,** J. A. Mawdsley, W. Brutsaert, *J. Hydraulics Div., Proc. ASCE* **99,** 99-110, 1973.

039-08675-820-00

THE REDUCTION OF GROUNDWATER STORAGE BY SUBSIDENCE

(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and applied research.
(*e*) The classical elastic approach has often been inadequate in the case of subsiding aquifers. The present study deals with the applicability of alternative models on the basis of recent developments in soil rheology. The results are tested with field data from the San Joaquin Valley.

CORNELL UNIVERSITY, Sibley School of Mechanical and Aerospace Engineering, Ithaca, N. Y. 14850. Professor E. Resler, Director.

041-08780-060-54

TURBULENCE, FLOW INTERACTION AND JETS, BUOYANT FLOWS

(*b*) National Science Foundation.
(*c*) Benjamin Gebhart, Professor of Mechanical Engineering.
(*d*) Basic and applied experimental and theoretical research, largely laboratory, some field.
(*e*) Our principal studies of the last two years have concerned 1) theory ofmultiple plume and plume-surface interactions, successfully compared with measurements; 2) measurement of nonlinear disturbance growth in a vertical flow; 3) detailed measurements of transition region mechanisms of a vertical flow, in both stratified and unstratified media; 4) identification of a predictive parameter for the beginning of transition; 5) heat transfer from "partial" surfaces, and the shed plumes; 6) heat transfer and the flow generated by a heated cylinder in stratified salt water; 7) axisymmetric laminar plume flow arising from combined thermal and mass diffusion buoyancy effects; 8) closed form solutions for some combined buoyancy-mode flows; 9) analysis of horizontal, radial, laminar flows; 10) horizontal, plane, laminar flow, second order boundary layer analysis; 11) disturbance growth characteristics in vertical flows, in air and water, generated through the combined buoyancy effects of thermal and mass diffusion; 12) measurement of transition of the plane plume.
(*f*) We are continuing in directions 2), 3), 4), 5) and 11) above and beginning new studies in the nature of first full turbulence and its downstream development, in water; buoyancy-induced flows in fresh and saline water under conditions leading to local density extrema; measure transport rates for a vertical ice surface melting in water; the generation of accurate property relations for fresh and saline water around the density extremum; instability and transition mechanisms in flows adjacent to inclined surfaces; determination of instability and transition in vertical flows generated by simultaneous chemical species and thermal diffusion; instability and transition characteristics of a vertical flow subject to motion in the ambient fluid; reduction of temperature and velocity sensor data taken in and over a corn canopy.
(*g*) See (h).
(*h*) **An Experimental Study of Nonlinear Disturbance Behavior in Natural Convection,** B. Gebhart, Y. Jaluria, *J. Fluid Mech.* **61,** pp. 337-365, 1973.

An Experimental Study of the Transition of Natural Convection Flow Adjacent to a Vertical Surface, B. Gebhart, F. Godaux, *Intl. J. Heat Mass Transfer* **17,** pp. 93-107, 1974.

Transport Processes Induced by a Heated Cylinder Submerged in a Salt Stratified Medium, B. Gebhart, R. H. Hubbell, *24th Heat Transfer and Fluid Mech. Inst.*, Corvallis, Oreg., June 1974.

Buoyancy Induced Flows Adjacent to Horizontal Surfaces, B. Gebhart, P. Blanc, *Proc. 5th Intl. Heat Transfer Conf.*, Tokyo, Sept. 1974.

Axisymmetric Flows Resulting from the Combined Buoyancy Effects of Thermal and Mass Diffusion, B. Gebhart, J. C. Mollendorf, *Proc. 5th Intl. Heat Transfer Conf.*, Tokyo, Sept. 1974.

On Transition Mechanisms in Vertical Natural Convection Flow, B. Gebhart, Y. Jaluria, *J. Fluid Mech.* **66,** 2, pp. 309-337, 1974.

Stability and Transition of Buoyancy-Induced Flows in a Stratified Medium, Y. Jaluria, B. Gebhart, *J. Fluid Mech.* **66,** 3, pp. 593-612, 1974.

The Transition of Plane Plumes, R. G. Bill, B. Gebhard, *Intl. J. Heat Mass Transfer* (to appear).

On the Buoyancy Induced Flow Arising from a Heated Hemisphere, Y. Jaluria, B. Gebhart, *Intl. J. Heat Mass Transfer* (to appear).

Laminar Plume Interactions, L. Pera, B. Gebhart, *J. Fluid Mech.* (to appear).

Second Order Boundary Layer Effects in Plane, Horizontal Natural Convection Flow, P. Blanc, B. Gebhart (in preparation).

Stability of a Vertical Flow Arising from Combined Buoyancy Modes, A. Boura, B. Gebhart (in preparation).

A Closed Form Solution for Some Combined Buoyancy-Mode Plume Flows, A. Boura, B. Gebhart (in preparation).

UNIVERSITY OF DELAWARE, College of Marine Studies, Newark, Del. 19711. Dr. W. S. Gaither, Dean.

042-08855-420-20

PHOTO-OPTICAL DETERMINATION OF SHALLOW WATER WAVE SPECTRA

(*b*) Geography Programs, Office of Naval Research, Department of the Navy.
(*c*) Dr. V. Klemas, Associate Professor.
(*d*) Experimental theoretical and field investigation; applied research.
(*e*) Derivation of shallow water spectra by employing optical Fourier analysis of aerial photographs and correlating with spectra of same waves obtained with airborne laser profiler and wave probes on towers outside the surf zone. Rapid survey of coastal wave conditions for amphibious operations and construction.
(*g*) Field work has been completed and correlation of remotely sensed and ground probe data continues.
(*h*) **Photo-Optical Determination of Shallow-Water Wave Spectra,** V. Klemas, J. Borchardt, L. Hsu, G. Gredell, N. Jensen, *Proc. Intl. Symp. on Ocean Wave Measurement and Analysis*, New Orleans, La., Sept. 9-11, 1974.

042-08856-450-50

SPACECRAFT STUDIES OF COASTAL CURRENT CIRCULATION AND SUSPENDED SEDIMENT CONCENTRATION

(*b*) Earth Resources Satellite and Skylab Programs, National Aeronautics and Space Administration.
(*c*) Dr. V. Klemas, Associate Professor.
(*d*) Experimental, theoretical and field investigation, applied research.
(*e*) Determination of estuarine and shelf current circulation using air-dropped, air-traced drogues and dyes with integrated ship-aircraft-satellite system. Gross circulation patterns are derived from satellite images and correlated with ground measurements. Mapping suspended sediment concentration using digital analysis of ERTS-1 imagery and water samples collected from boats and helicopters. Delaware Bay and overseas sites. Determine identity, location, concentration, movement and dispersion of sludge and acid plumes caused by ocean dumping of wastes.
(*g*) High degree of correlation obtained between satellite image radiance in the red band (band 5) and suspended sediment concentration, inverse Secchi depth, and current circulation in the upper two meters of the water column.
(*h*) **Dye and Drogue Studies of Spoil Disposal and Oil Dispersion,** V. Klemas, D. Maurer, W. Leathem, P. Kinner, W. Treasure, *J. Water Pollution Control Federation* **46,** 8, Aug. 1974, pp. 2026-2034.
Skylab and ERTS-1 Investigations of Coastal Land Use and Water Properties, V. Klemas, D. Bartlett, R. Rogers, *AIAA/AGU Conf. Scientific Experiments of Skylab*, Huntsville, Ala., Oct. 30-Nov. 1, 1974.
Coastal and Estuarine Studies with ERTS-1 and Skylab, *Remote Sensing of Environment* **3,** 153-174, 1974.
Correlation of Coastal Water Turbidity and Circulation with ERTS-1 and Skylab Imagery, V. Klemas, M. Otley, W. Philpot, R. Rogers, *Proc. 9th Intl. Symp. Remote Sensing of Environment*, Apr. 15-19, 1974, Ann Arbor, Mich.

DESERT RESEARCH INSTITUTE, University of Nevada System, Center for Water Resources Research, Reno, Nev. 89507. Dr. George B. Maxey, Director of Center.

The following research projects are reported in Water Resources Research Catalog:

043-0326W-820-33

SOME APPLICATIONS OF STATISTICAL METHODS TO GROUNDWATER FLOW SYSTEMS ANALYSIS

See WRRC **7,** 2.0969.

043-0327W-860-33

OPTIMAL BASIN DEVELOPMENT AND WATER ALLOCATION WITH CONSIDERATION OF RESTRICTED WATER SUPPLY CONDITIONS, PHASE II

See WRRC **7,** 6.0788.

043-0328W-820-33

SELECTED PHYSICAL PARAMETERS RELATING TO MANAGEMENT ALTERNATIVES FOR RECHARGE AND FLOOD CONTROL ON ALLUVIAL FANS

See WRRC **7,** 6.0790.

043-0329W-860-33

ARID BASIN MANAGEMENT MODEL WITH CONCURRENT QUALITY AND FLOW CONSTRAINTS, PHASE I

See WRRC **9,** 4.0145.

043-0330W-820-33

DESCRIPTION, USE AND REFINEMENT OF A TWO-DIMENSIONAL, DIGITAL GROUNDWATER FLOW MODEL

See WRRC **8,** 2.0908.

043-0331W-820-33

INFLUENCE OF NEAR-SURFACE CALICHE DISTRIBUTION ON INFILTRATION CHARACTERISTICS, LAS VEGAS VALLEY, NEVADA

See WRRC **8,** 2.0909.

043-0332W-860-33

DIGITAL MODELING OF GROUND AND RIVER WATER INTERCHANGE, WINNEMUCCA BRANCH OF HUMBOLDT RIVER, NEVADA

See WRRC **8,** 2.0910.

043-0333W-860-33

DEVELOPMENT AND MANAGEMENT OF GROUNDWATER AND RELATED ENVIRONMENTAL FACTORS IN ARID ALLUVIAL AND CARBONATE BASINS IN WESTERN NEVADA, PHASE II

See WRRC **8,** 4.0193.

043-0334W-860-33

A STUDY OF THE EFFECTS OF WATERSHED CHARACTERISTICS AND LAND USE PRACTICES UPON WATER QUALITY AND SUSPENDED SEDIMENT PRODUCTION

See WRRC **8,** 4.0195.

043-0335W-820-33

EFFECT OF WATER MANAGEMENT ON QUALITY OF GROUNDWATER AND SURFACE RECHARGE IN LAS VEGAS VALLEY

See WRRC **8,** 5.1486.

043-0336W-860-33

WATER MANAGEMENT PRACTICES FOR OPTIMUM CROP PRODUCTION

See WRRC **8,** 5.1487.

043-0337W-870-33

TIME VARIANT CHARACTERISTICS OF WASTE WATER QUALITY CONTROL PLANTS

See WRRC 8, 5.1488.

043-0338W-870-33

NUTRIENTS AND SUSPENDED SEDIMENTS FOR THE CARSON, WALKER AND TAHOE-TRUCKEE RIVER BASIN

See WRRC 9, 4.0146.

043-0339W-310-33

EVALUATION OF FLOOD PEAK PREDICTION METHODS IN SEMI-ARID REGIONS IN RELATION TO DAM SAFETY

See WRRC 9, 8.0337.

043-0340W-820-33

INTRINSIC DIFFUSION IN GROUNDWATER AND SURFACE WATER SYSTEMS, PHASE I

See WRRC 9, 1.0020.

043-0341W-200-33

NUMERICAL SIMULATION OF UNSTEADY FLOW HYDRAULICS OF TRUCKEE RIVER

See WRRC 9, 6.0579.

043-09261-820-33

GROUNDWATER AND SURFACE WATER INTERRELATIONSHIPS IN A SEMI-ARID REGION: A CASE STUDY OF THE TRUCKEE MEADOWS REACH OF THE TRUCKEE RIVER, NEVADA

(*b*) Office of Water Research and Technology.
(*c*) Dr. Vulli Gupta.
(*d*) Applied.
(*e*) By means of linking surface and groundwater models this research will determine the hydraulic response in the shallow groundwater system of the Truckee River. To formulate a based model of the coupled system its basic hydraulics must be understood. This includes values and distribution of hydraulic and hydrogeologic parameters, the role of transfer vs loading effects on groundwater hydrographs, and the depth of response of the groundwater system to surface water stage changes, including the role of clay strata as barriers. Yet, it is generally not possible to completely specify all possible aspects of the hydraulics of the system independently of the model itself. Thus, study of uniqueness and sensitivity of the model in terms of parameter variations, and comparisons of parameters resulting from "best fit" criteria with those resulting from other means are a necessity. This research is a first attempt to investigate the application of linked groundwater and surface water models to a real situation in terms of all of these aspects of modeling theory.

043-09262-070-33

THE ROLE OF DEFORMATION OF THE POROUS MEDIUM IN UNSTEADY GROUNDWATER FLOW

(*b*) Office of Water Research and Technology.
(*c*) Dr. Richard L. Cooley.
(*d*) Theoretical.
(*e*) The theory of unsteady groundwater flow usually incorporates all of the effects of stress changes (and resulting strain) in the porous medium into a single constant termed specific storage creating a single differential equation analogous to the heat conduction equation to describe the fluid flow field. Another evolution of this theory has been the concept that stress and strain are incorporated explicitly through equations which describe stress-strain relationships. Very little work has been done to evaluate the magnitude of the error due to consideration of all of the effects of strain in a single constant. A solution to the combined stress-strain flow theory has not been developed but is highly probable in the near future. The objective of this study is to obtain a preliminary assessment of the role of stress and resulting strain in the porous medium in the determination of the groundwater flow field resulting from unsteady flow. This objective will be met by reviewing pertinent literature. From this review will emerge recommendations and a research plan for further study.

043-09263-070-33

CONSIDERATION OF TOTAL ENERGY LOSS IN THE THEORY OF FLOW TO WELLS

(*b*) Office of Water Research and Technology.
(*c*) A. B. Cunningham.
(*d*) Theoretical.
(*e*) Pumping test data and well design are based on radial flow from an aquifer. Studies now show that water entering a well usually concentrates at the upper end of the screen, resulting in a definite vertical component to the velocity in the aquifer in the region immediately surrounding the well. This research will formulate a complete thory for the behavior of groundwater in the vicinity of pumping wells. A mathematical statement of the combined energy losses in the well, through the well screen, and in surrounding porous medium will be developed, as well as solutions to selected cases which will be used to assess the importance of energy loss in the well in terms of the effect of these losses on the flow system around the well. The cases to be examined will involve unsteady flow due to pumping a well at a steady rate in a multi-aquifer system. Use of these cases will provide significant results both from the standpoint of field occurrence and existence of considerable standard theory.

043-09264-820-33

TRANSFORM APPROACH TO NUMERICAL MODELING OF GROUNDWATER SYSTEMS

(*b*) Office of Water Research and Technology.
(*c*) Dr. Clinton Case.
(*d*) Theoretical.
(*e*) Groundwater simulation is generally accomplished through use of finite difference or finite element approximation of the partial differential equation in space and time. Numerous algorithms have been devised to solve the resulting matrices. Because of computer space limitations and necessary computational time, three-dimensional simulation has to date been impractical as have been simulation models of large two-dimensional problems where any degree of precision was desired in either time or space. This project will undertake development of a new groundwater simulation technique that may circumvent the problems of dimensionality and computational time. This technique will involve removal of partial differentials by successive transformation. Theoretically this approach would allow direct solution of the governing equations in the transformed system at any point in space and time for values of hydraulic head or flow without the necessity of iterating solutions or stepping through time. This new approach, if successfully developed, will enable accurate simulation of any large two-dimensional or three-dimensional systems.

043-09265-340-33

INVESTIGATION OF WIND-HYDRO POWER GENERATION FOR SUPPLYING DEMANDS AT REMOTE LOCATIONS

(*b*) Office of Water Research and Technology.
(*c*) John W. Fordham.
(*d*) Applied.
(*e*) This study will provide utility companies with basic information on providing alternate sources of energy to remote locations. The objectives are a general assessment of potential needs of specific sites in Nevada for electrical energy to be provided by a wind-hydro system, and to develop a rationale for analysis, design and operation of a

wind-hydro system by examining the temporal variability of the wind data and water supply. The power capability of such a combined system at specific sites using transferred existing wind data and local hydrologic conditions will be studied as well as the ability of such a system to shape generation to load, and the feasibility of using wind-hydro generation as a secondary supply for mining and milling operations. An examination of the economic viability of this alternative source of electrical energy will also be made by comparing estimated wind-hydro costs with alternative energy sources.

UNIVERSITY OF DETROIT, College of Engineering, Civil Engineering Department, 4001 W. McNichols Road, Detroit, Mich. 48221. Dr. Eugene Kordyban, Associate Professor.

044-07979-130-00

INVESTIGATION OF THE MECHANISM OF SLUG FORMATION IN TWO-PHASE HORIZONTAL FLOW

(*d*) Experimental and theoretical basic research.
(*e*) Basic nature of wavy and stratified air-water flow is being studied theoretically and experimentally to determine the conditions under which the slugs will form.
(*g*) At present the basic behavior of interfacial waves and their influence upon air flow are being investigated. The aerodynamic pressure in air has been determined as well as the interfacial shear. The wave characteristics, such as speed, height to length ratio and the internal flow patterns are being studied.
(*h*) **Some characteristics of Aerodynamic Pressure Over High Waves in Closed Channels**, E. Kordyban, *ASME Paper 73-FE-6.*
Interfacial Shear in Two-Phase Wavy Flow in Closed Horizontal Channels, E. Kordyban, *Trans. ASME, J. of Fluids Engr.* **96**, p. 97, 1974.
The Highest Waves in Two-Phase Flow, E. Kordyban, *Cavitation and Polyphase Forum - 1974*, ASME publication.

DUKE UNIVERSITY, Department of Mechanical Engineering and Materials Science, Durham, N. C. 27706.

045-09003-270-20

HEAT AND MASS TRANSFER IN THE HUMAN RESPIRATORY TRACT AT HYPERBARIC PRESSURES

(*b*) Office of Naval Research.
(*c*) Professor L. S. Linderoth, Jr.
(*d*) Experimental and theoretical; applied research; Doctoral thesis.
(*e*) Preliminary work conducted to establish a mathematical model for the heat and mass transfer in the human respiratory tract under hyperbaric conditions. The experimental work is conducted at one atmosphere using air only as the environmental fluid. Results are extrapolated for HeO_2 breathing gas mixtures to depths of 1,000 feet sea water. Experimental velocity and temperature profiles are recorded for a scaled symmetrical model of the trachea and the first two bifurcations of the human respiratory tract. Gas properties and psychrometric charts for pressurized HeO_2 environments are developed. A basic computer program is developed to calculate the pertinent breathing gas properties and to predict the respiratory heat loss of a diver to depths of 2,000 feet sea water.
(*f*) Completed.
(*g*) See (e).
(*h*) Annual progress report **Heat and Mass Transfer in the Human Respiratory Tract at Hyperbaric Pressures,** L. S. Linderoth, Jr., E. A. Kuonen, Office of Naval Research Contract N-00014-67-A-0251-00018, May 1973.

045-09004-270-20

HEAT AND MASS TRANSFER IN THE LOWER TRACT OF THE HUMAN LUNG AT HYPERBARIC CONDITIONS

(*b*) Office of Naval Research.
(*c*) Professor L. S. Linderoth, Jr.
(*d*) Experimental; applied research; Master's thesis.
(*e*) The heat loss from the human respiratory tract was investigated at hyperbaric pressures for different gas mixtures by means of an instrumented heated symmetric model of the trachea and the first two airway bifurcations. Heat transfer characteristics of the branching model were determined. Heat transfer coefficients were obtained for a range of respiratory rates and respiratory gas mixtures for simulated ocean depths of 0 to 1000 feet. The results were used to predict the heat loss from the respiratory tract of a diver. A method for predicting gas temperatures at various segments of the lung is presented.
(*f*) Completed.
(*h*) Annual Progress Report, **Heat and Mass Transfer in the Human Respiratory Tract at Hyperbaric Pressures,** L. S. Linderoth, Jr., M. L. Nuckols, E. E. Johnson, Office of Naval Research Contract N-00014-67-A-0251-00018, July 1974.

045-09005-270-20

DEEP DIVING RESPIRATORY HEAT AND MASS TRANSFER

(*b*) Office of Naval Research; North Carolina Heart Association.
(*c*) Professor L. S. Linderoth, Jr.; C. E. Johnson, Research Assistant.
(*d*) Experimental and theoretical; applied research; Doctoral thesis.
(*e*) Airways of laboratory dogs are instrumented with microthermistors (10 mil diameter). The subjects are then exposed to hyperbaric environmental conditions of cold temperatures and HeO_2 breathing mixtures to simulate the environmental conditions experienced by the deep diver. Proximal gas stream temperatures and lumen wall temperatures are recorded. Cast models of the dog's asymmetrical respiratory tract are instrumented and artifically ventilated under similar environmental conditions. Temperatures of the gas stream and lumen wall are recorded, the results are compared to the in vivo studies, and utilized in defining the heat transfer boundary conditions during various phases of hypothermic exposure. A mathematical model is developed to predict the local heat loss in the respiratory tract during various exposures in the ocean environment.

045-09006-000-54

VISCOUS INCOMPRESSIBLE FLOW BETWEEN ECCENTRIC COAXIALLY ROTATING SPHERES

(*b*) National Science Foundation.
(*c*) Dr. Bruce Munson, Dept. of Engrg. Science and Mechanics, Iowa State University, Ames, Iowa.
(*d*) Theoretical; basic research.
(*e*) Streamlines, angular velocity, and torque compared to concentric spheres.
(*f*) Completed.
(*g*) The motion of a viscous fluid contained between two eccentric rotating spheres is obtained as a perturbation valid through first-order terms in the Reynolds number and second-order terms in a parameter describing the eccentricity.
(*h*) **Viscous Incompressible Flow Between Eccentric Coaxially Rotating Spheres,** B. R. Munson, *Physics of Fluids* **17**, 3, pp. 528-531, Mar. 1974.

045-09007-270-00

VISCOUS ENERGY DISSIPATION IN A MODEL OF THE HUMAN BRONCHIAL TREE

(*c*) R. W. Douglass.
(*d*) Experimental; applied research; Master's thesis.

(*e*) Experimental measurement of velocity and static pressure distributions and viscous energy dissipation in a two generation rigid wall model of the human bronchial tree at large Reynolds numbers.
(*f*) Completed.
(*h*) **Viscous Energy Dissipation in a Model of the Human Bronchial Tree,** R. W. Douglass, B. R. Munson, *J. Biomechanics* 7, pp. 551-557, 1974.

045-09008-000-54

FLOW IN A ROTATING SPHERICAL ANNULUS

(*b*) National Science Foundation.
(*c*) Dr. B. R. Munson, Dept. of Engrg. Science and Mechanics, Iowa State University, Ames, Iowa.
(*d*) Experimental and theoretical; basic research; Doctoral thesis.
(*e*) Theoretical and experimental investigation of laminar flow, flow stability (linear stability theory), and turbulent flow in concentric and eccentric coaxially rotating spherical annulus.
(*f*) Completed.
(*h*) **Viscous Incompressible Flow Between Concentric Rotating Spheres. Part 3. Linear Stability,** B. R. Munson, M. Menguturk, *J. Fluid Mech.* (in press), 1975.

UNIVERSITY OF FLORIDA, Coastal and Oceanographic Engineering Laboratory, College of Engineering, Gainesville, Fla. 32611.

046-09087-400-54

TRANSVERSE CIRCULATION AND MASS TRANSPORT IN ESTUARIES

(*b*) National Science Foundation.
(*c*) Y. H. Wang.
(*e*) A laboratory apparatus is designed to create a stably stratified flow field with longitudinal and transverse circulation. The approach is to use salt as the stratifying agent in a two-layer flow system. Various degrees of interfacial mixings from stepwise to uniform distributed density profiles are achieved. Instantaneous velocities are measured by hot-film anemometer. Instantaneous densities are measured by a laboratory-made, single-electrode conductivity probe. The experimentally determined diffusion coefficients due to longitudinal and transverse circulation effects are separated and compared with Fischer's (1972) theoretical work. The non-linear boundary effects and their roles in estuarine circulation are examined and discussed.

046-09088-420-54

TRANSMISSION OF LARGE AMPLITUDE WAVES THROUGH NARROW OPENINGS

(*b*) National Science Foundation.
(*c*) U. Unluata.
(*e*) Investigate the effects of flow separation and the basic linearities on the transmission of shallow water waves through narrow openings. The harmonic distortion of incident long waves, as a result of dissipative and nonlinear flow at a narrow aperture, is studied to infer the changes in the frequency response characteristics of a bay or a harbour that is present on the transmission side of the aperture. Particular attention is paid to asymmetry to inquire into a significant steady current that may be generated because of the uneven energy losses suffered over each wave period. The generation of such steady currents has its significance in the flushing mechanism of bays.

046-09089-420-00

PROPAGATION OF LONG-WAVES OVER SHEAR FLOWS IN THE PRESENCE OF STRATIFICATION

(*c*) U. Unluata.
(*e*) The propagation of initially monochromatic water waves and internal waves over shear currents is investigated. The energy pumping from the fundamental to higher harmonics through non-linear interactions is studied with special attention to the dependence of the rate of energy pumping on shear and stratification.

046-09090-410-00

MONITORING RESTORED BEACH AT JUPITER ISLAND

(*c*) O. H. Shemdin.
(*e*) Over 2.97 million cubic yards of sand were placed on the beach at Jupiter Island along a 5.0 mile stretch. Construction began in May 1973 and was interrupted in October of the same year to avoid the winter storms. The remaining one-third of the construction commenced in June 1974 and the total project was completed in July. The Coastal and Oceanographic Engineering Laboratory began monitoring the beach fill in April 1974 to complement the monitoring program established by the project engineer whose primary task is to obtain hydrographic surveys of the fill semi-annually. The COE Laboratory contribution is to provide measurements of the environmental factors which cause sand movement. The total monitoring program is scheduled for one year, i.e., May 1975. The measurements will include the following: 1) wave height by a pressure gage and direction by visual observations from the beach, 2) seasonal hydrographic surveys at 400 foot intervals to include beach and offshore profiles, 3) current measurement and direction at a depth of 20 feet, 4) tide and wind recording, 5) sand samples and representative cores at many locations and 6) a sand tracing study to assess the longshore and offshore movements.
The data obtained will be analyzed to obtain the following results: 1) the volume and percentage of sand removed from the restored beach over a period of one year, 2) the rate of littoral drift in intense storms if such occur, 3) sorting and movement of sand in the offshore direction and 4) the rate of littoral drift will be evaluated from sand tracing studies and compared with available data.

046-09091-410-44

NEARSHORE CIRCULATION, LITTORAL DRIFT AND THE SAND BUDGET OF FLORIDA

(*b*) Sea Grant, NOAA.
(*c*) O. H. Shemdin.
(*e*) To continue: 1) development of a Coastal Engineering Archives; 2) prepare glossary of inlets reports and work up data on inlets; 3) quantify inlet sand budgets and determine potential of inlet outer bars as a location for nourishment material for beach nourishment projects; 4) determine by a field study the rate and direction of littoral drift at Panama City, Florida; 5) to develop a pilot system capable of being used to determine littoral drift along Florida's shoreline and to check past analytically computed values of littoral drift; 6) to monitor and study beach nourishment projects to find out where sand placed on beaches is going, and to determine if presently developed analytical models of onshore/offshore and longshore sand movements are correct; 7) to support Marine Advisory Program.
The primary emphasis of this study is to identify and quantify beach erosion mechanisms and to implement these results into rational recommendations for beach erosion control. Additionally, a coastal engineering specialist has been added to the staff and provides a communications link with the users in coastal counties. Research results and advice for particular problems are conveyed to the user and also problem areas which may require research effort are identified. A coastal engineering archives is being established at the University of Florida to serve as a source for historical information relating to Florida's shoreline and as a depository for unique documents of interest to the coastal engineer and planner.

046-09092-410-20

DYNAMICS AND MORPHOLOGY OF INLETS ON SANDY COASTS

(*b*) Office of Naval Research.
(*c*) M. P. O'Brien.
(*e*) It is important for navigational purposes to be able to predict currents in a tidal inlet and the tide in the bay connected to the ocean through the inlet. While some inlets have fairly stable channels which require little maintenance, others exhibit migratory trends and are prone to closure under the influence of wave activity and associated sand transport. In as much as dredging maintenance of unstable inlet channels is generally an expensive operation, it is necessary to evaluate the stability of the inlet in quantitative terms in order to facilitate remedial measures. The ultimate purpose of the project is therefore to a) obtain generalized predictive methods for currents in the inlet and tides in the bay, given the inlet-bay geometry and ocean tides, and b) evaluate quantitative stability and closure criteria for tidal inlets. Also under investigation are the sediment transport capabilities of inlets and flushing characteristics of inlet-bay systems.

046-09093-410-65

MONITORING OF FILL SOUTH OF CANAVERAL JETTIES

(*b*) Brevard County and Department of Natural Resources.
(*c*) O. H. Shemdin.
(*e*) The beach south of Canaveral Harbor, Brevard County, will utilize sand dredged from the Poseidon Submarine base. A stretch of beach 2.2 miles long is to receive 2.7 million cubic yards of selected sand. Work is scheduled to begin in June 1974. Artificial replenishment of eroded beaches by pumping sand is a method that is gaining more acceptability and becoming a more viable and economically feasible method of protecting beaches in Florida. An understanding of the processes involved in sand movement is necessary and can be best achieved by closely monitoring restored beaches. The improved understanding will help not only in maintaining the restored beach, but also in planning for other restoration projects around the State of Florida.

046-09094-410-13

CRITERIA TO EVALUATE LITTORAL DRIFT ALONG PANAMA CITY BEACHES

(*b*) Mobile District, Corps of Engineers; and Bureau of Beaches and Shores, Florida Department of Natural Resources.
(*c*) J. A. Purpura.
(*e*) This two year study is to evaluate the magnitudes and directions of littoral sand drift along the shoreline of Panama City Beach, Florida, to evaluate future performance of beach nourishment projects at that location. The study will entail the building of an experimental groin at the site and continuous monitoring of the beach changes at the groin and of the waves affecting the beach by surveys, time lapse photography, and wave height and direction recording instrumentation.

046-09095-410-60

A STUDY OF FEDERALLY MAINTAINED INLETS IN FLORIDA

(*b*) Florida Department of Natural Resources.
(*c*) J. A. Purpura.
(*e*) Much of Florida's highly developed beach areas are in critical need of sand replacement (beach renourishment). There is an apparent shortage of compatible sand to renourish beaches. One of the most readily available sources of compatible renourishment sand is in the various inlet complexes throughout this state. The purpose of this study is to investigate the disposition and volumes of sand that have been dredged from Federally maintained inlets and the resulting impact, if any, on adjacent beaches.

046-09096-410-60

COASTAL ENGINEERING STUDIES RELATED TO FLORIDA'S SHORELINE AND BEACH EROSION PROBLEMS

(*b*) Bureau of Beaches and Shores, Florida Department of Natural Resources.
(*c*) J. A. Purpura.
(*e*) This long-range investigation to define causes and provide solutions to beach erosion will be focused on segments of the State's coastline with the most pressing problems. Research will primarily involve: the role of inlets in contributing to shoreline problems, general coastline susceptibility to wave attack using refraction techniques, the performance of various types of coastal protective structures and the availability of nearshore sand resources suitable for beach nourishment.

046-09097-450-54

FIELD STUDY OF THE HYDRODYNAMIC EFFECTS OF HURRICANES ON COASTAL WATERS

(*b*) National Science Foundation.
(*c*) M. P. O'Brien and O. H. Shemdin.
(*d*) Field study.
(*e*) Quantitative information of the storm surge, the waves and the currents induced by the high wind velocities and the low pressure of hurricanes on the shallow waters of the coastal zone is in a primitive state. Few tide gates are located on the open coast where the surge reaches its maximum elevations and those in place seldom survive the storm. High water marks and records at inland gages have provided useful available information on water levels. Current and wave measurements are almost non-existent in the area of maximum storm effects.
Three-quarters of the damage and loss of life caused by major hurricanes have been the result of flooding, wave action and strong currents. The violent nature of hurricanes, their random occurrence in time and location, and the erratic paths followed present a severe problem of instrumentation. In order to assure a high probability of obtaining data in a reasonable period of time, one must either install a large number of fixed recording stations or provide a highly mobile measurement system. It is proposed that simple, rugged instrument bases be prepared in advance at many locations along the coasts and inland waters of Florida but that a limited number of instrument systems be provided for installation only at those prepared bases nearest the predicted path of each hurricane. The prepared bases would consist of deeply embedded piles fitted for rapid attachment of the instrument packages.

046-09098-450-00

HIGH WIND OVER SHALLOW WATER

(*c*) O. H. Shemdin.
(*e*) Florida coastal water and shores are frequently subjected to hurricane winds which produce damage by inundation and by direct wind action. This research is directed at evaluating the effect of wind on water on the open coast and in inlets and waterways. A portion of the effort is devoted to the design of a storm tide facility and to develop the techniques for the laboratory simulation of wind, tides, waves and currents. A major study on hurricanes is developed under this program.

046-09099-340-73

MODEL INVESTIGATION OF PUBLIC SERVICES OFFSHORE NUCLEAR POWER PLANT

(*b*) Public Service Electric and Gas Company.
(*c*) R. G. Dean
(*e*) The Public Service Electric and Gas Company plans to install a generating facility three miles offshore from the coast of New Jersey. The facility includes two floating nuclear power plants moored inside an artificial harbor

created by two breakwaters. Two models have been used to study specific aspects of the design. A 1:196 scale model has provided preliminary data concerning the orientation of the breakwaters and the response of the floating plants under various wave conditions. A detailed 1:64 scale model has been used to study the effect of ship collisions with the breakwater and, for extreme and operating wave conditions, forces in the mooring system, plant motions, breakwater stability and pressures on the platform hulls. Further investigation will include the near-field thermal effects of the cooling water discharge from the facility.

046-09100-420-44

LABORATORY INVESTIGATION OF CAPILLARY WAVES

(*b*) NOAA.
(*c*) O. H. Shemdin.
(*e*) Remote sensing applications in oceanography are receiving much attention in view of the recent use of space vehicles for ocean exploration. Field and laboratory measurements are being coordinated with aircraft and satellite observations to determine the effectiveness of remote sensing methods. This laboratory study is aimed at providing water surface information, on waves and breaking of waves, to air remote observations.
The objectives of the investigation are: 1) to study under a controlled environment, the two-dimensional behavior of high frequency waves at different wind speeds, fetch, and in the presence or absence of swell. This is done as a means of evaluating the radar scattermeter. 2) To study the formation and properties of white caps as a function of wind speed to evaluate the use of the microwave radiometer as an instrument to measure wind speed.

046-09101-420-11

STREAM FUNCTION REPRESENTATION OF HURRICANE-GENERATED IRREGULAR WATER WAVES

(*b*) Coastal Engineering Research Center.
(*c*) R. G. Dean.
(*e*) The capability of a water wave theory to accurately predict the water particle motions associated with waves generated by hurricanes has not been tested by field measurements. Waves generated by Hurricane Carla in September 1961, were recorded from an offshore oil platform in the Gulf of Mexico and the data are available to the public through the National Oceanographic Data Center. These wave data will be used: 1) to determine the capability of the irregular Stream Function Wave Theory to accurately represent design features (water particle motions and pressures) of hurricane generated waves; 2) to determine the relative wave height ranges for which the Stream Function and Linear Theories provide the best agreement with these measured features and 3) to determine the effect of directionality and nonlinearity on the accuracy of the Stream Function Theory to represent hurricane-generated waves.

046-09102-870-73

THERMAL EFFECTS IN LOWER BISCAYNE BAY AND CARD SOUND

(*b*) Florida Power and Light Company.
(*c*) R. G. Dean.
(*e*) Construction of two nuclear power plants has been completed at Turkey Point, about 30 miles south of Miami, Florida. In an attempt to better understand the adjacent Biscayne Bay, Card Sound system, a program was undertaken to: 1) obtain field data relating to motions of bay waters and water exchange through the various inlets to the Atlantic Ocean and other connecting waters, and 2) to develop a numerical model for representing the motions and flushing of the bay waters. At present most of the collection of field data is complete and the data are being used to calibrate the numerical model.

046-09103-410-10

FIELD INVESTIGATIONS TO DETERMINE PERFORMANCE OF PONCE DE LEON IMPROVEMENT PLAN, FLORIDA

(*b*) U. S. Army Corps of Engineers.
(*c*) J. A. Purpura.
(*e*) Investigate through field measurements and tracings, the performance of a system of jetties, a jetty-weir and an impoundment basin recently constructed to stabilize the Ponce de Leon Tidal Inlet and the effect of this system on the adjacent coastline. Baselines have been established. Field and aerial surveys revealed very important and rapid coastline changes. Monitoring will continue.

046-09104-420-54

LABORATORY INVESTIGATION OF GENERATION AND GROWTH OF WIND WAVES

(*b*) National Science Foundation.
(*c*) O. H. Shemdin.
(*e*) The available techniques in predicting the growth of waves under the action of wind are sufficiently accurate. This research is aimed at providing a more analytical base for forecasting wind waves.
The research is experimental using laboratory facilities, but is intimately connected with existing theories on wave generation. The purpose is to verify the limits of validity of existing theories and to propose a basis for future theoretical formulation.

046-09105-410-00

DEVELOPMENT OF FIELD AND MOBILE STATIONS

(*c*) O. H. Shemdin.
(*e*) The rapid population increase in the State of Florida coastal areas coupled with the predominately eroding beaches has imposed the need for research facilities located on the coast for studying coastal phenomena. By a special legislative appropriation, funds were made available to a) develop a permanent field station on the Florida east coast, b) develop a mobile field station and c) provide critically needed information on beach erosion. The permanent field station will serve to test new instruments, train coastal engineering students and to collect climatological data on winds, waves and tides. The mobile field station will be used to conduct on-site studies in different coastal areas and to plant instruments in studies related to hurricanes. Two research projects will be initiated a) to gather information on causes and effects of sand movement placed on the beach in artificial nourishment projects and b) to study runup of waves. The research is aimed at providing needed information for engineering design.

046-09106-420-54

FIELD MEASUREMENT OF SURFACE PRESSURE WITH A WAVE FOLLOWER

(*b*) National Science Foundation.
(*c*) O. H. Shemdin.
(*e*) Recent measurements of fetch limited wave spectra in the North Sea and calculations of nonlinear wave-wave interactions in a gravity wave spectrum suggest the importance of nonlinear interactions in influencing wave growth in a fetch limited field situation. A field experiment on an international scale to measure simultaneously wave growth and atmospheric input to waves in the North Sea was conducted during the Summer of 1975. The project plan is to design, construct and test a wave follower on which a pressure sensing system is mounted. The system is to measure atmospheric pressure above waves simultaneously with water surface displacement to compute atmospheric energy transfer to waves. The wave follower is designed for operation in the North Sea. The results obtained from the North Sea Experiment participation in 1973 demonstrated that the University of Florida wave fol-

lower is a sea worthy wave follower and suitable for oceanic studies. The University is invited to participate in a number of research activities which critically depend on the use of such an apparatus.

046-09107-420-70

WAVE FORCE ANALYSIS AND DESIGN PROCEDURE DEVELOPMENT

(*b*) Amoco Production Company-Manager (Seventeen Companies Participating).
(*c*) R. G. Dean.
(*e*) Water wave forces on two offshore pile supported platforms in the Gulf of Mexico were recorded during Wave Projects I and II and are available to the public through the National Oceanographic Data Center. These data have been analyzed using water particle kinematic fields predicted by the Stream Function Wave Theory to provide the oil industry with an improved design procedure for predicting the water wave and current forces on piles. A procedure to simulate non-linear undirectional seas has been formulated and compared with the data. Present efforts are concentrating on developing an improved working relationship to represent the non-deterministic nature of the sea surface and associated forces.
The results of this research will be an improved design procedure for use in calculating wave forces and movements on offshore structures.

046-09108-420-65

A REVIEW OF STORM TIDE STUDY IN PINELLAS COUNTY, FLORIDA

(*b*) Board of County Commissioners, Pinellas County.
(*c*) T. Y. Chiu and J. A. Purpura.
(*e*) The Federal Insurance Administration (FIA) aided by the National Oceanic and Atmospheric Administration, U. S. Army Corps of Engineers and the U. S. Geological Survey, is currently establishing the 100-year frequency storm flood elevations in coastal areas along the Florida shoreline. Such storm flood elevations proposed for certain portions of the unincorporated area of Pinellas County are considered to be too high by local interests. In response to a request made by the Board of County Commissioners of Pinellas County, a program has been initiated to perform the necessary and special services required to compile factual data and develop procedures for projecting reasonable and justifiable 100-year frequency storm flood elevations for joint consideration and review by the FIA. Some errors in the numerical modeling have been found and after modification of the numerical model of Tampa Bay, the water surface slope under the 100-year frequency storm has been reduced considerably.

046-09109-870-70

EVALUATION OF THE FLUSHING CHARACTERISTICS OF THE PROPOSED CANAL SYSTEM IN FLAGLER COUNTY, FLORIDA

(*b*) ITT Community Development Corporation.
(*c*) T. Y. Chiu and J. A. Purpura.
(*e*) Due to the magnitude of a proposed vast canal system to be connected to the Intracoastal Waterway through an existing canal in Flagler County, a project has been initiated to study the flushing characteristics of the canal system and its impact on the waterway. Two numerical models are being built. The first one is to represent the entire water system from Matanzas Inlet to Ponce de Leon Inlet, including existing and proposed canal systems. The flushing characteristics of the waterway and the impact of the proposed canal system on the waterway will be evaluated by this model. The second numerical model is to represent the existing and proposed canal systems. Their flushing characteristics will be evaluated by this model in conjunction with the first model. Field measurements of tides, currents, winds and dispersion coefficients (dye study) have been completed.

046-09110-420-20

LABORATORY INVESTIGATION OF INTERNAL WAVES

(*b*) Office of Naval Research.
(*c*) D. M. Sheppard.
(*e*) Questions regarding the precise mechanism by which these waves are generated remain to be answered, even though a number of well formulated theories have been advanced. The need for quantitative experiments to reinforce or repudiate these theories is evident. The proposed research is intended to fulfill this need through a series of carefully planned and conducted experiments in a versatile 2 ft x (ft x 80 ft internal wave tank. This apparatus has the capability of providing shear flows in a two fluid or a continuously stratified fluid system. In addition, mechanical waves can be generated at the surface and at the interface between two fluids. A blower system provided the capability of generating wind waves at the upper fluid surface. Obstacles may be placed on the bottom to generate lee waves.

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THE FRANKLIN INSTITUTE RESEARCH LABORATORIES, Mechanical and Nuclear Engineering Department, The Benjamin Franklin Parkway, Philadelphia, Pa. 19103. W. H. Steigelmann, Manager, Energy Engineering Laboratory.

047-07820-340-00

FLOW MODELING STUDIES FOR GAS- AND WATER-COOLED REACTORS

(*d*) Experimental.
(*e*) Several flow model studies have been made using pressurized carbon dioxide to simulate the flow of pressurized water and helium in nuclear reactors. The use of pressurized carbon dioxide permits high Reynolds numbers to be attained because of the unusually low kinematic viscosity of this fluid. An incidental advantage is that the required pressures are obtained by charging the supply tanks with dry ice, so that compressors are not needed as part of the facility. Measurements made with the CO_2 flow model include flow distribution, pressure distribution, and mixing. Flows are generally measured by sensing the pressure drops across orifices that simulate the hydraulic resistance of flow passages. Flow patterns in other regions have also been studied by injecting cooled carbon dioxide at suitable inlet points and measuring the temperature distribution at downstream points by means of sensitive thermistor elements. The differential pressure and temperature data are recorded automatically on punched cards which provide the input information for a computer program that automatically analyzes and processes the data.

047-07821-340-00

FLOW MODELING STUDIES FOR SODIUM-COOLED REACTORS

(*d*) Experimental.
(*e*) In one nuclear reactor flow modeling study, the upper plenum coolant flow was modeled using water as the modeling fluid. Injection of an electrolyte into the water simulated the sudden drop in reactor core outlet temperature following a shut-down. By measuring electrical conductivity as a function of time near the model outlet, data were obtained from which the thermal shock to the outlet nozzle could be inferred. Another flow model was used to study the core flow distribution in the EBR-II reactor. Water was used in this model, also, permitting the free surface of the coolant in the upper plenum to be simulated. The influence of the proximity of the flow passages upon the effective pressure available to the sideward-facing entrance holes was inferred from flow distribution measurements, permitting adjustment of the hole sizes to yield the desired flows.

7-07822-000-00

YNAMICS OF ROTATING FLUIDS

e) Oscillation of the free surface of a rotating fluid contained in a cylindrical cavity was investigated. The fluid was assumed to be rotating initially with a Couette-type velocity distribution in a stable configuration. The effects of fill ratio and the initial velocity profile on the frequencies of the subsequent motion were established. The results were of interest in the study of the exterior ballistics of spin-stabilized shells containing non-solid fillers.

7-07823-000-00

SCOUS FLOW WITH MOVING BOUNDARY AND FREE SURFACE

d) Theoretical.

e) The practical problem of transporting a lubricating oil by means of a partially immersed rotating wheel led to the development of the theory of viscous streamline flow on a vertical upward-moving surface in the presence of a gravitational field when there is a free surface. The approach used was to equate the shear stress at a point in the liquid, due to the weight of liquid at large distances from the moving solid boundary, to the product of viscosity and velocity gradient. The range of possible values for the thickness of the liquid layer was then determined by the condition that the velocity at the free surface is between zero and the value for which total transport of liquid is a maximum. The rate of transport of liquid was found by integrating the resulting velocity distribution.

47-08676-870-36

TOMIZED WATER INJECTION TO IMPROVE DRY COOLING TOWER PERFORMANCE

(b) Energy Research and Development Administration.
(c) George Peter Wachtell, Principal Scientist.
(d) Experimental and theoretical; applied research.
(e) Atomized water was injected into the air stream of an air cooled heat exchanger, in an indoor test and in outdoor tests with two commercial heat exchangers. The purpose was to assess the improvement in heat exchanger performance due to adiabatic cooling of the air, and also due to evaporation inside the heat exchanger when excess water was injected. Theoretical and experimental observations were made of the effect of droplet size on undesirable fin wetting, and on ability to adiabatically cool the air to nearly the wet bulb temperature.
(f) Completed.
(g) With droplets on the order of 20 microns, substantial improvement in performance of a power station using a dry cooling tower can be achieved by adiabatic cooling nearly to the wet bulb temperature. Some further benefit can also be obtained by injecting excess water, but much smaller droplets are required.
(h) Final report in process.

Atomized Water Injection to Improve Dry Cooling Tower Performance, G. P. Wachtell, Franklin Inst. Res. Labs., Phil., Pa., Nov. 1974, prepared for USAEC (now ERDA), Division of Reactor Research and Development, Under Contract No. AT (11-1)-2241, *Report No. C00-2241-1, UC-12.*

GENERAL DYNAMICS CORPORATION, ELECTRIC BOAT DIVISION, Eastern Point Road, Groton, Conn. 06340. J. R. Hunter, Director of Engineering.

048-09024-870-33

AN EXPERIMENTAL STUDY OF THE FREE SURFACE EFFECTS ON A BUOYANT JET

(b) Office of Water Research and Technology.
(c) Bernard S. Ryskiewich, Engineering Specialist, Advanced Engineering Department.
(d) Experimental applied research.
(e) The effect of the water surface on a submerged, round, turbulent, buoyant jet has been investigated experimentally. The jet discharge variables were taken over a broad range which covers most cases of practical interest. The results provide valuable data which will enable a power plant coolant discharge designer to execute his design with confidence in the jet plume behavior and surface effect.
(f) Completed.

GENERAL ELECTRIC COMPANY, NUCLEAR ENERGY DIVISION, 175 Curtner Avenue, San Jose, Calif. 95125. R. G. Bock, Manager, Development Applications.

049-07988-140-52

BLOWDOWN HEAT TRANSFER PROGRAM

(b) General Electric Company, Electric Power Research Institute, and Energy Research and Development Administration.
(c) G. W. Burnette, Mail Code 584.
(d) Experimental and theoretical, applied research.
(e) Program to provide data on transient heat transfer during conditions representative of a boiling water reactor undergoing hypothetical loss-of-coolant accident. Specific investigations include time to boiling transition, lower plenum swell hydrodynamics and core thermal response, and post-boiling transition and lower plenum swell heat transfer. Early tests oriented toward feasibility and reliability of proposed heaters (electric resistance heating of outer sheath) in multirod arrays for use at elevated temperatures. Final year of three-year program devoted to heat transfer in full-size, full-power test bundles.
(g) Both 16-rod and the first (of two) 7 x 7 electrical heater rod bundle blowdown heat transfer test series have demonstrated the presence of inherent cooling mechanisms during the blowdown period prior to the availability of emergency core cooling systems. Results have shown large safety margins when current design methods are supplied to predict the sealed reactor systems' hydraulic and thermal response.
(h) All documents listed may be obtained through Technical Information Center, P. O. Box 62, Oak Ridge, Tenn. 37830.

BWR Blowdown Heat Transfer First Quarterly Progress Report, July 1 - September 30, 1972, *GEAP-13317-01.*

BWR Blowdown Heat Transfer Third Quarterly Progress Report, January 1 - March 31, 1973, *GEAP-13317-03.*

BWR Blowdown Heat Transfer Fourth Quarterly Progress Report, April 1 - June 30, 1973, *GEAP-13317-04.*

BWR Blowdown Heat Transfer Fifth Quarterly Progress Report, July 1 - September 30, 1973, *GEAP-13317-05.*

BWR Blowdown Heat Transfer Program, Task C-4 Report, Preliminary System Design Description of Two-Loop Test Apparatus – Revision 1, G. W. Burnette, D. W. Danielson, K. A. Nilsson, Nov. 1973, *GEAP-13276-1.*

BWR Blowdown Heat Transfer Program, Task A2 Report, 49-Rod Bundle Test Plan, Jan. 1974, *GEAP-13318.*

BWR Blowdown Heat Transfer, Sixth Quarterly Progress Report October 1 - December 31, 1973, *GEAP-13317-06.*

BWR Blowdown Heat Transfer, Seventh Quarterly Progress Report, January 1 - March 31, 1974, *GEAP-13317-07.*

Task B Topical Report; Evaluation of Direct Heaters and Hydrodynamic Measurement Techniques Under Simulated LOCA Conditions in a Single-Loop Test Apparatus, R. J. Muzzy, G. W. Burnette, K. A.. Nilsson, G. L. Sozzi, J. P. Walker, K. D. Wing, June 1974, *GEAP-20512.*

BWR Blowdown Heat Transfer Program, Eighth Quarterly Progress Report, April 1 - June 30, 1974, *GEAP-13317-08.*

GENERAL ELECTRIC COMPANY, RE-ENTRY AND ENVIRONMENTAL SYSTEMS DIVISION, P. O. Box 8555, Philadelphia, Pa. 19101. Dr. Eric Softley, Manager, Ocean Sciences Laboratory.

051-08677-440-44

ANALYSIS OF LAKE SHORE ICE FORMATION, GROWTH, AND DECAY

(*b*) NOAA through what is now Great Lakes Environmental Research Laboratory as part of the International Field Year on the Great Lakes (IFYGL).
(*c*) J. F. Dilley, Rm. 1322M/VFSC.
(*d*) First year, experimental; second year, analytical; basic research.
(*e*) Field data taken during the winter of 1972-73 at Nine Mile Point, on the southern shore of Lake Ontario is used as a basis for the analysis. A numerical simulation model was developed to analyze the detailed heat transfer during periods of ice formation, growth, and decay, which is the purpose of the study. The model computes the time varying temperatures and ice thickness in a vertical plane, perpendicular to the shoreline.
(*g*) The water near shore was observed to be well mixed vertically and thus the water temperature would drop to 0° in depth before surface freezing would commence. Ice usually forms onshore first not primarily because of heat extracted by the land mass but because of less thermal mass (because of smaller depths) and increased surface heat transfer due to wave action.
(*h*) **IFYGL Near Shore Ice Formation Growth and Decay–Comprehensive Phase 1 Summary,** A. Pavlak, *G. E./RESD TIS No. 73SD229*, July 1973.
Analysis of Lake Shore Ice Formation, Growth, and Decay – IFYGL Phase 2 Final Report, J. F. Dilley, A. Pavlak, *G. E./RESD Rept. No. 74SD2155* (available Great Lakes Environmental Research Lab., Ann Arbor, Mich. 48104).

051-08678-870-36

SWIRL CONCENTRATOR FOR COMBINED SEWER OVERFLOWS AND PRIMARY TREATMENT OF SEWAGE

(*b*) American Public Works Association as managing agent on a research grant from the Environmental Protection Agency.
(*c*) Dr. R. R. Boericke; Consultant, Oceans and Environmental Sciences.
(*d*) Theoretical, basic research.
(*e*) Develop computer models to predict the flow patterns and particle concentration distribution in a swirl chamber device for separating grit and sewage from combined sewer overflows, and for primary treatment of sewage. A numerical relaxation technique is used to solve the equations for turbulent axisymmetric flow, written in terms of the stream function, vorticity, and a rotation parameter. A three-dimensional eddy viscosity model is used to relate the local turbulent Reynolds stresses to the gradients of the mean flow properties. The suspended solids concentration is then determined from the transport equation, including turbulent diffusion.
(*g*) Computer models have been developed and checked out. Results compare favorably with physical model studies performed by LaSalle Hydraulics Laboratory.
(*h*) **Mathematical Model for Swirl Chamber Combined Sewer Solids Separator,** R. Boericke, C. Koch, H. Gilman, *GE/RESD TIS 72SD220*, May 1972.
The Swirl Concentrator as a Combined Sewer Overflow Regulator Facility, *EPA-R2-72-008*, USGPO ($2.25).
Mathematical Model of the Swirl Concentrator as Applied to Primary Separation of Sewage and Combined Sewer Discharges, R. Boericke, C. Koch, R. DeMoyer, *GE/RESD TIS 72SD227*, June 1974.

051-08679-400-73

ESTUARINE HYDRAULICS AND THERMAL DISPERSION

(*b*) Consolidated Edison Co. of New York, Inc.
(*c*) Dr. R. R. Boericke; Consultant, Oceans and Environmental Sciences.
(*d*) Theoretical, applied research.
(*e*) Develop and validate two-dimensional time-dependent numerical models for the prediction of hydraulics and thermal dispersion in estuaries. The three-dimensional (XYZ) solution is approximated by separate simulations in the XZ and XY planes. The solution in the XZ plane is obtained by numerically integrating the continuity, momentum, and energy equations on a computational grid spanning the longitudinal (X) and vertical (Z) directions. The XY model provides the solution to these equations in the longitudinal (X) and lateral (Y) directions. The two models are coupled together to provide definition of the three-dimensional temperature distribution throughout the tidal cycle. The XZ model formulation includes the pressure gradient terms arising from longitudinal salinity variations, and can therefore predict salinity-induced circulation patterns.
(*g*) Computer models have been developed and checked out. Present effort centers on validation of these models by comparisons with field data.
(*h*) **Hydraulics and Thermal Dispersion in an Irregular Estuary,** R. R. Boericke, D. W. Hall, *J. Hyd. Div., Proc. ASCE* **100,** HY1, Jan. 1974.
Final Report, XY Hydraulic/Thermal Model, R. R. Boericke, *Rept. No. 74SD2172*, General Electric Co., RESD, 3198 Chestnut Street, Phila., Pa., 19101, Oct. 10, 1974.
Final Report, XZ Hydraulic/Thermal Model, R. R. Boericke, *Rept. No. 74SD2318*, General Electric Co., RESD, 3198 Chestnut Street, Phil., Pa. 19101, Dec. 31, 1974.

051-08680-050-73

JET INTERACTION STUDY

(*b*) American Electric Power Service Corp.
(*c*) Dr. R. R. Boericke; Consultant, Oceans and Environmental Sciences.
(*d*) Theoretical, applied research.
(*e*) Develop a model for predicting the local circulation patterns induced by cooling water discharges in a shallow lake.
(*f*) Completed.
(*g*) A time-dependent numerical model based on the vertically integrated equations of continuity and momentum in two dimensions was developed. Results were obtained for several configurations of multiple discharge jets interacting with a weak ambient current. The calculated flow patterns agree favorably with those observed in dye studies of a physical model.
(*h*) **Interaction of Multiple Jets with an Ambient Current,** R. R. Boericke. *J. Hyd. Div., Proc. ASCE* **101,** HY4, April 1975.

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GEORGIA INSTITUTE OF TECHNOLOGY, School of Civil Engineering, Atlanta, Ga. 30332. Paul H. Sanders, Assistant Director.

052-06693-070-00

SOLUTIONS OF SEEPAGE THROUGH COMPLEX MEDIA BY FINITE ELEMENTS

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical; basic research.
(*e*) Seepage through naturally occurring materials frequently requires treatment of media which are seldom isotropic and more often nonhomogeneous. The method of finite elements is a general numerical method by which complicated seepage problems can be effectively conditioned for digital computation.
(*h*) **Solution of Anistropic Seepage by Finite Elements,** O. Zienkiewicz, Y. K. Cheung, *J. Engrg. Mech. Div., ASCE Proc.* EM1, Feb. 1966, pp. 111-120.
Numerical Modeling in Fluid Mechanics, B. R. Olmstead, *M.S. Thesis*, Ga. Inst. Tech., Sept. 1968, 79 pages.

052-06695-250-61

UNSTEADY FLOW OF DILUTE AQUEOUS HIGH POLYMER SOLUTIONS IN PIPES

(*b*) Water Resources Center.
(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and experimental; basic research.
(*e*) Small traces of certain long-chain polymeric molecules, dissolved in water, reduce turbulent friction in flow through pipes. Local additions of polymers will change the resistance characteristics almost instantly, and the progress of the fluid slug with changed properties is a time dependent process. A mathematical study of head and velocity changes is to be carried out using numerical procedures and an electronic digital computer. The mathematical problem is to be formulated as an initial value problem. Solutions to simple pipe problems involve the Runge-Kutta procedures and the Adams-Bashforth method. A laboratory study of unsteady pipe flow is to verify the mathematical model. The mathematical procedures are to be extended to parallel pipe systems and to pipe networks.
(*g*) Experiments carried out in a 2-inch diameter pipe demonstrated that a 40 percent reduction resulted from admixture of 100 parts per million by weight. Reductions as much as 60 percent were observed at polymer concentrations of 300 parts per million. The experiments were carried out as steady-state processes. The basic simple pipe unsteady flow problem has been solved numerically. Laboratory experiments are under way to verify the procedures.
(*h*) **Unsteady Flow of Aqueous Solution of Long-Chain Polymers in Pipe Networks,** H. C. Jackson, *M.S. Thesis*, Ga. Inst. Tech., Jan. 1970, 135 pages.
Unsteady Flow of Dilute Aqueous Polymer Solutions in Pipe Networks–A Method to Improve Water Distribution, *WRC Rept. 0170*, Water Resour. Ctr., Ga. Inst. Tech., Feb. 1970, 139 pages.

052-06699-430-00

DYNAMIC RESPONSE FUNCTIONS OF OCEAN STRUCTURES

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical; Ph.D. thesis.
(*e*) Develop a technique for analyzing the dynamic response of off-shore structures subjected to random wave forces and to the constraints imposed by the foundation medium of the ocean floor. Emphasis is placed on the use of existing models of the forcing functions and the restraining functions to formulate a numerical method analysis. The structural model is analyzed for free and random vibrations. Cross-power spectra are developed for random force fields and random wave heights. Consideration is given to fluid damping and the effects of vortex shedding. Dynamic resistance of soils to the movements of piles is to be included. The finite element method may be used in the analysis of dynamic foundation response.
(*h*) **Dynamic Structure-Soil-Wave Model for Deep Water,** *J. Waterways, Harbors and Coastal Engrg. Div., ASCE*, Paper No. 7889, Feb. 1971, pp. 107-184.
An Analysis Technique for Composite Structures Subject to Dynamic Loads, *Trans. ASME* **38,** Series E, 1, Mar. 1971, pp. 118-124.

052-07298-130-00

AIR ENTRAINMENT IN ENCLOSED CONDUITS

(*c*) Dr. C. S. Martin.
(*d*) Experimental; basic and applied research.
(*e*) The formation of hydraulic jumps in sloping conduits and the transition from bubbly flow to slug flow in a vertical shaft are currently being studied. Model studies were conducted on an outfall line for the purpose of removing air entrained by moving hydraulic jumps. Air was removed by using simulated air release valves. Entrainment of air into vertical shaft through Borda-type entrances is being studied. Air demand at inlet is measured. Instability of nappe and resultant pressure fluctuations and vibrations are being measured and studied. Formation of slug flow and subsequent blow back or blow out is also being studied.
(*h*) **Transition from Bubbly to Slug Flow of a Vertically Downward Air-Water Mixture,** C. S. Martin, *Flow Studies in Air and Water Pollution*, ASME Symp., Atlanta, Ga., 1973, pp. 49-60.
Vertically Downward Bubbly and Slug Flows of An Air-Water Mixture in a Pipe, C. S. Martin, Institut für Hydromechanik, Univ. Karlsruhe, Karlsruhe, Germany, July 1972, 160 pages.
Characteristics of an Air-Water Mixture in a Vertical Shaft, C. S. Martin, *Proc. 21st ASCE Hydraul. Spec. Conf.*, Bozeman, Mont., Aug. 15-17, 1973, pp. 323-334.

052-07300-220-00

TRANSPORT CHARACTERISTICS OF LOG-NORMAL DISTRIBUTED BED MATERIALS IN OPEN CHANNELS

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and experimental; Ph.D. thesis.
(*e*) Information is sought on the interaction of the turbulence structure in open channel flow and the bed load movement of log-normally distributed bed materials. Time-dependent measurements are made of sediment transport and size distributions. Turbulence measurements are made with a constant temperature hot-film anemometer. The phenomenon of armoring is investigated.
(*h*) **An Experimental Study of Bed Armoring,** *Proc. Einstein Sediment Symp.*, Univ. Calif., Berkeley, June 1971.

052-08010-350-73

EFFECT OF PIER SHAPES AND PIER LOCATIONS ON SPILLWAY CAPACITIES

(*b*) Georgia Power Company.
(*c*) Dr. P. G. Mayer.
(*d*) Applied research.
(*e*) Laboratory studies are conducted to obtain design criteria. 1:100 and 1:60 hydraulic models are tested.
(*f*) Completed.
(*g*) The tests made in order to establish the capacity of the spillway for the Wallace Dam Project were carried out on a 1:60 scale partial model. The test results showed conclusively that the most probable flood of some 307,000 cfs can be accommodated with the reservoir surface elevation at 440 feet MSL. The accommodation of the most probable flood over the spillway requires that the crest control Tainter gates be completely open. The entrance to the spillway was modeled with two different abutment configurations at the powerhouse. One was a quarter-circular abutment, the other was a semi-circular pier extension into the reservoir. The quarter-circular abutment resulted in flow separation at the powerhouse wall and in unsteady flows which would also result in pressure fluctuations on the powerhouse wall. The semicircular pier extension allowed the flow to remain attached, and both the flow separation and the expected pressure fluctuations were thus eliminated. In order to establish the effectiveness of the energy dissipator, a series of tests were carried out. The variables included the range of flows, the radius of a flip bucket, the invert elevations of the bucket, the exit angle, and the geometry of the wingwall between the spillway and the tailrace of the powerhouse. An optimum combination of the variables resulted when the flip bucket had a 60-foot radius, an exit angle of 25 degrees, a bucket invert elevation of 333 feet, and when the wingwall was at an elevation of 335 feet.
(*h*) **Vortex Phenomena at Hydraulic Intake Structures,** presented at *ASCE, Water Resources Mtg.*, Los Angeles, Calif., Jan. 21-25, 1974.

052-08011-340-73

RESERVOIR CIRCULATION IN A PUMPED-STORAGE PROJECT

(*b*) Georgia Power Company.
(*c*) Dr. P. G. Mayer.

(*d*) Theoretical, applied research.
(*e*) A 30 x 50 foot laboratory model was built on a distorted scale (1:400 horizontal, 1:60 vertical). Studies being conducted to establish near-field and far-field circulation patterns. The project is designed to provide design information for the Wallace Dam Pumped-Storage Project of the Georgia Power Company.

052-08012-360-73

CROSS-FLOW ASSISTED HYDRAULIC JUMPS

(*b*) Georgia Power Company.
(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and applied research.
(*e*) Cross-flow assisted hydraulic jumps form at conjugate depths less than those predicted by two-dimensional momentum analysis. The studies are intended to explain the phenomena and to establish design criteria.

052-08013-350-00

SPILLWAY CREST PRESSURES AT PARTIALLY OPEN TAINTER GATES

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and applied; M.S. thesis.
(*e*) Dam spillway standard crest shapes are often designed for about 75 percent of the design head in order to obtain greater discharge capacity. This procedure results in negative pressures which have been measured. The addition of Tainter gates as crest control structures provides for the opportunity to discharge from partially open gates. The jet trajectory from the partially open Tainter gates is different from that used for the design of the standard overflow spillways. The study is intended to delineate the limiting condition which would prevent the occurrence of cavitation and cavitation damage.

052-08014-740-00

FINITE ELEMENT ANALYSIS IN FLUID MECHANICS

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical.
(*e*) Development of detailed mathematical and numerical analysis involved in the finite element method. A computer program is developed and selected applications are studied.
(*h*) **The Fate of Radionuclides in a Groundwater Environment,** *Proc. Intl. Symp. on Finite Element Methods in Flow Problems*, Swansea, Great Britain, Jan. 7-11, 1974 (with C. V. Smith).

052-08814-210-54

EFFECT OF ENTRAINED AIR ON PRESSURE TRANSIENTS

(*b*) National Science Foundation.
(*c*) Dr. C. S. Martin.
(*d*) Experimental and analytical; Doctoral research.
(*e*) A two-year research effort has just begun on the investigation of the effect of gases, free and dissolved, on pressure transient phenomena in pipelines. As gases may be present in the dissolved and/or in the entrained state in cooling water systems of thermal power stations, in sewage pumping lines, or in crude oil lines, the effect of the compressibility of any entrained gas on the wave propagation speed, and on any resulting pressure transient, must be ascertained to perform a proper analysis. In addition to problems concerning the prediction of pressure changes in dispersed mixtures in pipelines for which flow changes occur due to valve operation or machine behavior, the effect of entrained gas on resonating frequencies may likewise be important. An experimental apparatus has been built to produce a steady flow of an air-water mixture in a plexiglass pipeline. By means of valve operation, sudden, gradual, or oscillating, the pressure transients will be produced. For sharp pressure changes the wave propagation speed and amplitude variation along the pipeline will be determined. The dissipative and dispersive nature of the mixture as well as the formation of shocks will be ascertained.

052-08815-040-00

EFFLUX FROM A DOUBLE-OPENING SLOT

(*c*) Dr. C. S. Martin.
(*d*) Theoretical.
(*e*) The two-dimensional flow of an inviscid fluid out of two openings at the end of a rectangular conduit has been solved using free streamline techniques. The solution is an extension of the work by von Mises, who investigated the efflux out of symmetrical and asymmetrical single slots. A technique was developed for solving the boundary value problem in a plane for which the logarithm of the velocity and the direction of the velocity satisfied Laplace's equation. Numerical results were obtained for two symmetric openings, each of which was asymmetric on its respective side.

052-08816-030-00

PERIODIC MOTION OF A ROLLING SPHERE ON A BOUNDARY

(*c*) Dr. C. S. Martin.
(*d*) Experimental.
(*e*) The steady state motion of spheres rolling on a smooth plane boundary under the influence of simple harmonic water motion is being investigated. The experimental arrangement consists of a large U-tube, which has a cross section 4 ft wide by 1 ft deep, and a air pressure forcing system which can generate water displacements up to 1.5 ft in each direction. The natural period of the system is fixed at 3.56 sec by the geometry of the facility. Steady-state amplitudes and phase angles of spheres of various sizes and specific gravities are measured for various amplitudes. The final objective is the determination of the inertial and resistance coefficients.

UNIVERSITY OF HAWAII, Department of Civil Engineering, 2540 Dole Street, Honolulu, Hawaii 96822. Dr. John A. Williams, Professor.

053-07309-820-61

MODEL STUDIES OF TIDAL EFFECTS ON GROUNDWATER HYDRAULICS

(*b*) Water Resources Research Center.
(*d*) Experimental and theoretical, applied research.
(*e*) Hydraulic, electric analog, and mathematical models were used to study the response to tidal changes of aquifers in communication with the sea. Both confined and unconfined homogeneous and isotropic aquifers of simple boundary geometry were considered. Emphasis was placed on the determination of aquifer properties from observed responses to tidal fluctuations.
(*f*) Completed.
(*g*) Results indicate that both diffusion theory and the electric analog model can be used to describe the propagation of tidal-induced fluctuations through a porous media, provided that the diffusion coefficients account for capillary rise in unconfined aquifers and for changes in the compressibility of the media in confined aquifers.
(*h*) **Model Studies of Tidal Effects on Groundwater Hydraulics,** J. A. Williams, R. Wada, R. Wang, *WRRC Tech. Rept. 39*, Univ. of Hawaii, Honolulu, 1970.

053-07310-820-61

ANALOG SIMULATION OF TIDAL EFFECTS ON GROUNDWATER AQUIFERS

(*b*) Water Resources Research Center.
(*d*) Experimental and theoretical, applied research.
(*e*) This project is essentially a continuation of (07309) above. The response to tidal changes of semi-infinite aquifers having discontinuous changes in permeability and average depth and of finite aquifers with linearly varying permeabilities are to be studied. Determination of aquifer proper-

ties from observed responses to tidal fluctuations is the basic goal of the study.

(*f*) Completed.

(*g*) Results indicate that the use of tidal response data to determine aquifer properties yields results which are generally different from and probably less reliable than the use of pump test data. The optimum analyses for aquifer properties would include both techniques.

(*h*) **The Response to Tidal Fluctuations of Two Nonhomogeneous Coastal Aquifer Models,** J. A. Williams, T. C. Liu, *WRRC Tech. Rept. 51*, Univ. of Hawaii, Honolulu, 1971.

The Response to Tidal Fluctuations of a Leaky Aquifer System, J. A. Williams, T. C. Liu, *WRRC Tech. Rept. 66*, Univ. of Hawaii, Honolulu, 1973.

An Experimental Study of the Response of Deep Aquifers to Tidal Changes, T. C. Liu, *M.S. Thesis in Civil Engrg.*, Univ. of Hawaii, Honolulu, 1973.

The Response to Tides of Coastal Aquifers: Analog Simulation vs. Field Observation, J. A. Williams, T. C. Liu, *WRRC Tech. Rept. 86*, Univ. of Hawaii, Honolulu, 1975.

053-07311-420-00

LABORATORY STUDY OF THE RUN-UP OF A DOUBLE-HUMPED WAVE IMPINGENT ON A PLANE SLOPING BEACH

(*b*) Conducted as part of the Joint Tsunami Research Effort, Hawaii Institute of Geophysics, under the direction of Drs. William M. Adams and Gaylord Miller. The large scale experiments are being carried out at the Look Laboratory for Oceanographical Engrg., Dept. of Ocean Engrg., Univ. of Hawaii, Mr. J. T. O'Brien, Lab. Director.

(*d*) Experimental, basic research.

(*e*) The object of these tests is to validate the numerical predictions of wave runup by J. P. Butler (*HIG Report 67-16, Aug. 1967*) which are based on a theoretical analysis by Carrier and Greenspan (*JFM, 4, 97, 2958*).

A wave generator, composed of a series of evenly spaced solid strips with their bottom edges contoured to the inverse of the desired double-humped profile, was dropped into the water in such a way that the leading edge of the wave generator coincided with the beach. Two-wire resistance probes located between two adjacent strips of the generator recorded the water surface as the resulting "humps" of water propagated into the beach.

(*f*) Completed.

(*g*) The predicted runup based on Carrier and Greenspan's (1958) work was verified for smooth beaches for the class of double-humped waves tested.

(*h*) **A Laboratory Model of a Double-Humped Wave Impingent on a Plane Sloping Beach,** J. A. Williams, J. M. Jordaan, Jr., in *Tsunamis in the Pacific Ocean*, W. M. Adams (ed.), East-West Center Press, Honolulu, Hawaii, 1970.

Run-Up of Double-Humped Waves, J. A. Williams, *Look Laboratory, Hawaii* **1**, 4, Univ. of Hawaii, Honolulu, Oct. 1970.

Run-Up of a Double-Humped Wave Impingent on a Plane, Sloping Beach, J. A. Williams, *Hawaii Inst. of Geophysics Rept. HIG-71-8 (or NOAA-JTRE-55)*, Univ. of Hawaii, Honolulu, May 1971.

053-09046-870-61

SUBSURFACE WASTE DISPOSAL BY INJECTION IN HAWAII

(*b*) Water Resources Research Center.

(*c*) Professor F. L. Peterson, Dept. of Geology and Geosciences, or Prof. J. A. Williams, Dept. of Civil Engineering.

(*d*) A theoretical and experimental study as well as field observation.

(*e*) Determine the interaction between waste water injected and the Ghyben-Herzberg system. Hele-Shaw and digital models are to be used and their results correlated with field data.

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UNIVERSITY OF HAWAII, J. K. K. Look Laboratory of Oceanographic Engineering, Department of Ocean Engineering, 811 Olomehani Street, Honolulu, Hawaii 96813. John Thomas O'Brien, Director of the Laboratory. (Direct report requests to: The Director)

054-08111-410-44

SAND RECOVERY OFF HAWAII

(*b*) Office of Sea Grants, Natl. Ocean. and Atmos. Administration; Kamehameha Development Corp., Honolulu, Hawaii.

(*c*) F. M. Casciano.

(*d*) Development task in the ocean.

(*e*) To develop a Submarine Sand Recovery System (SSRS); to develop a recovery technique suitable for a small contractor; to involve local and other agencies in the task preferably with their financial support. The SSRS features a hydraulic dredge of the suction type with a head which is jetted to the bottom of a sand deposit. As sand is pumped out, to a barge or directly onto a beach, the material above collapses into the cavity formed. Eventually a stable crater is formed and sand removal ceases. The intake features a device to reduce clogging. It is a powered crusher-feeder which breaks down large particles such as coral chunks, before they enter the intake pipe. A 6 inch dia. suction head and related equipment have been successfully tested from a barge moored in 60 ft of unprotected water on the leeward side of the island of Hawaii.

(*f*) Completed.

(*g*) Approximately 10,000 yds^3 of sand were dredged in late 1974. A final report is in preparation. Environmental studies are continuing through 1975.

(*h*) **Effects of Sand Removal on a Coral Community, A Literature Review of,** J. Levin, *TR-19*, J. K. K. Look Lab., Dec. 1970, 78 pages.

Results of Tests of Submarine Sand Recovery System Off Island of Hawaii, F. M. Casciano, *TR-36*, J. K. K. Look Lab. (publication pending).

054-08112-420-60

HAWAIIAN SURF PARAMETERS

(*b*) State of Hawaii.

(*c*) J. R. Walker, c/o Moffatt and Nichol, P. O. Box 7707, Long Beach, Calif. 90807.

(*d*) Applied research mainly in the ocean aided by theoretical and experimental studies in the laboratory and some development (of an artificial reef mainly for surfing).

(*e*) The study was conducted "... so that shoreline projects can be planned and executed with improved knowledge relating to ocean wave phenomena especially relating to shoals and land masses...(and).. to obtain information...in order to protect and enhance safety, navigation activities, recreation facilities, and other shoreline interests..." (Act 175 of 1970 Hawaiian Legislature). Surf parameters, for a particular surfing area, include location, hydrography, winds, waves, currents, compositon of bottom, use, ingress-egress and effect on coastline.

(*f*) Completed.

(*g*) Surf parameters for recreational surfing areas in the Hawaiian Islands have been identified and measured along with their social and ecological significance. Recommendations are made for their development, preservation and enhancement.

(*h*) **Recreation Surfing in Hawaii,** J. R. Walker, R. O. Palmer, J. K. Kukea, *Proc. 13th Conf. Coastal Engrg., ASCE*, 1972.

Recreational Surf Parameters, J. R. Walker, *TR-30*, J. K. K. Look Lab., Feb. 1974, 374 pages.

Surf Parameters: Final Report (Part II); Social and Historical Dimensions, J. Kelly, *TR-33*, J. K. K. Look Lab., Nov. 1973, 251 pages.

Wave Transformations Over a Sloping Bottom and Over a Three-Dimensional Shoal (A Dissertation), J. R. Walker, *MR-11*, J. K. K. Look Lab., May 1974, 154 pages, *Ph. D. Thesis.*

054-08113-410-44

HAWAIIAN BEACH AND SURF PARAMETERS

(*b*) Office of Sea Grants, Natl. Ocean. and Atmos. Administration.
(*c*) F. Gerritsen.
(*d*) Applied research in nearshore area.
(*e*) Determine seasonal and long-term rates of sand loss or accretion; identify relationship among dominant parameters such as breaking, refraction, diffraction, surf, setup, surge, currents, sand transfer; predict extent of erosion; train students in pertinent techniques.
(*f*) Completed. Final report in progress.
(*g*) Various beaches on Oahu and neighbor islands have been studied with emphasis on beach developments at Waikiki. Erosion of beaches occurs primarily during periods of high wave activity. At Waikiki a major rip current develops during southern swell conditions, which is a significant factor in the development of erosion. Much can be learned from nature – stability of shoreline between natural formations – as to the most desirable structures for coast protection. Related model studies have provided information regarding the characteristics of breaking waves and the functioning of groin systems.

054-08114-870-65

WATER PROPERTIES OF KAILUA BAY, OAHU, HAWAII

(*b*) City and County of Honolulu, Hawaii.
(*c*) K. H. Bathen.
(*d*) Applied research in the ocean.
(*e*) Provide baseline information for a sewer outfall soon to be constructed in the Bay.
(*f*) Completed.
(*g*) Measurements were made of currents in the Bay and of temperature and salinity along with concentrations of certain nutrients especially derivatives of phosphorous and nitrogen. Analysis is directed to provide information especially on seasonal changes in circulation and water properties in the Bay and of dilution at the proposed outfall discharge points.
(*h*) **A Descriptive Study of the Circulation and Water Quality in Kailua Bay, Oahu, Hawaii, during 1971 and 1972,** K. H. Bathen, *TR-29*, J. K. K. Look Lab., Sept. 1972, 3 volumes: volume 1 (156 pages), volume 2 (169 pages), and volume 3 (144 pages).

054-08115-470-13

HYDRAULIC MODEL STUDY OF HALEIWA SMALL CRAFT HARBOR, OAHU, HAWAII

(*b*) Corps of Engineers, U.S. Army, Pacific Division, and University of Hawaii.
(*c*) T. T. Lee.
(*d*) Applied experimental type research in the laboratory, with limited field measurements for model verification, plus numerical model results.
(*e*) As an aid to design, to test and report on plans by the Corps for the improvement of the protection of the harbor against wind generated waves without disturbing adversely the beach east of the harbor entrance. The plans considered include deepening and the extension of the outer mole.
(*f*) Completed in November 1973.
(*g*) Nine plans were tested and evaluated with a 1:75 scale undistorted hydraulic model and the results were compared with those predicted by the numerical model developed by Loomis (1972). Best plan mainly on the basis of effectiveness as a wave attenuator is the Single-Jetty-with-Special-Channel, and best plan economically mainly on the basis of attenuation per unit length of obstruction is the Single-Jetty-with-Existing-as-Modified-Channel.
(*h*) **Hydraulic Model Study of a Small Boat Harbor Located at Haleiwa, Oahu, Hawaii,** T. T. Lee, *Misc. Rept. No. 3*, J. K. K. Look Lab. *Repts. 3A-3M* (progress reports), dated, respectively, Jan. 1972-Jan. 1973.
Wave Action in Haleiwa Harbor, Hawaii, T. T. Lee, M. A. Sklarz, J. C. Crittendon, R. Y. Rocheleau, D. Y. Y. Wong, *TR-32*, J. K. K. Look Laboratory, Oct. 1973, 341 pages.
Numerical Prediction of Harbor Response, T. T. Lee, M. A. Sklarz, presented *Symp. on Modeling Techniques for Waterways, Harbors, and Coastal Engrg.*, Sept. 3-5, 1975, San Francisco, Calif.
Behavior of Haleiwa Harbor During Storm of January 7, 1974, D. Y. Y. Wong, *M.S. Paper*, June 1974; Dept. of Ocean Engrg., Univ. Hawaii, 266 pages. (The study involved the application of the numerical model (Loomis, 1972) to hindcast the response of Haleiwa Harbor due to the Jan. 7, 1974 storm.)
A Package Program for Time Stepping Long Waves Into Coastal Regions With Application to Haleiwa Harbor, H. G. Loomis, *NOAA-JTRE-79*, Univ. Hawaii, Oct. 1972.

054-08116-470-13

EFFECT OF HYDRAULIC DREDGING IN KAWAIHAE HARBOR, HAWAII

(*b*) Corps of Engineers, U.S. Army, Pacific Division.
(*c*) F. Gerritsen.
(*d*) Applied experimental type research in the field.
(*e*) Objectives in this mainly coral based harbor are to obtain measurements of water quality in the dredge discharge system; siltation effects on the seabed and harbor bottom both around the areas being dredged and around the discharge system; dredging operation parameters for correlation with the aforementioned water quality and siltation measurements.
(*f*) Completed.
(*g*) Measurements were made of dredge output and of water circulation and tidal variation and the properties of the water including suspended and bed load, salinity and concentrations of nutrients such as derivatives of phosphorous and nitrogen.
(*h*) **Dredging Operation Monitoring Environmental Study, Kawaihae Harbor, Hawaii,** S. P. Sullivan, F. Gerritsen, *TR-25*, J. K. K. Look Lab., Sept. 1972, 180 pages.

054-08117-370-44

MARINE ALTERNATIVES FOR MASS TRANSIT IN HAWAII

(*b*) Office of Sea Grants, NOAA; State of Hawaii, Office of Marine Affairs Coordinator.
(*c*) T. T. Lee and L. H. Seidl.
(*d*) Literature-numerical study in the office, and field survey and measurements of selected waterways and drainage channels; and a seakeeping study of various vessels and terminals.
(*e*) Determine the feasibility of operating a fleet of boats for public transportation in the existing waterways in the Honolulu area as a complement to a land-based rapid transit system. The physical, economic, demographic and social environment has been studied along with the improvements and alterations required, such as dredging and bridge building and relocation. The prediction of the seakeeping characteristics of a variety of ferry vessels was made.
(*f*) Completed.
(*g*) Major efforts include study of the hydrological and oceanographic constraints, dredging requirements, canal feeder boat requirements and preliminary cost data. It was estimated that the total capital cost will be $23 million (1972) plus additional capital and replacement cost over 30-year period of $7 million. The annual cost was estimated to be $4 million including $271,000 annual cost for waterway system alone. Seakeeping study showed that the Navy SSP and Boeing 929 Hydrofoil offer desirable ride characteristics.
(*h*) **Engineering Investigation of Marine Alternatives for Rapid Transit in Hawaii,** T. T. Lee, S. A. Nicinski, to be issued June 1975 by the Office of Sea Grants, NOAA, Univ. of Hawaii.

A Pilot Study of Marine Alternatives for Mass Transit in Hawaii – Inland Waterways System, S. A. Nicinski, T. Kikuchi, T. T. Lee (being edited by Sea Grant Office, Univ. of Hawaii).
A Preliminary Feasibility Study – A Marine Transit as a Supplement to a Land-Based Rapid Transit System, L. H. Seidl, F. Gerritsen, P. Wybro, S. A. Nicinski, draft report completed December 1973.

054-08118-720-44

OPERATION OF HYPERBARIC FACILITIES

(*b*) Office of Sea Grants, NOAA.
(*c*) J. T. O'Brien.
(*d*) Operation, maintenance and development of hyperbaric facilities.
(*e*) A steel cylindrical tank called the "Deep Tank," 40 ft high and 30 ft in diameter with 40 inch OD hatch on top and side, is available. This can be filled with water and/or air to 4 atmospheres absolute (ATA). An 8 ft long by 40-inch OD cylindrical lock to 11 ATA is part of the side hatch. A four component diving system to 19 ATA is installed. It consists of two cylindrical decompression chambers each about 8 ft long and 54 inches OD; one 54-inch OD spherical lock and one 9 ft high by 72-inch OD cylindrical diving bell. A three component wet and/or dry facility to 100 ATA has been designed complete with plans, specifications and cost estimate. It consists of two cylindrical tanks, one 20 ft long by 8 ft OD and the other 10 ft long by 50 inches OD. Both are attached in line to either side of an 8-ft OD spherical lock. These facilities are operated for the benefit of researchers in general. To date the researchers have been from the Dept. of Physiology and concerned with Human Performance in the Sea.
(*f*) Firm through Aug. 1975.
(*g*) Studies currently on the way and planned in the Deep Tank include experiments with humans on breath-hold diving bradycardia, a reflex slowing of the heart, and on maximal submerged work capacity, especially as effected by temperature and water depth.
(*h*) **Human Performance in the Sea,** T. O. Moore, *Look Lab/Hawaii* **1**, 3, 42-43, July 1970.

054-08119-520-54

RESPONSE OF MOORED SHIPS TO IRREGULAR SEAS

(*b*) National Science Foundation.
(*c*) L. H. Seidl.
(*d*) Applied numerical type research in the office.
(*e*) To develop design diagrams for the prediction of the motion of ships moored in irregular seas. Conventional theory is being used along with computers.
(*f*) Completed.
(*g*) Significant double amplitudes of surging, heaving, and pitching motions of moored ships in irregular seas have been calculated and plotted as ship length versus the motion for sea states 3 through 7. Computation of the amplitudes of the other three motions has been done.
(*h*) **Swaying, Rolling and Yawing Response Operators of Moored Vessels,** P. G. Wybro, L. H. Seidl, *TR-26*, J.K.K. Look Lab., Oct. 1972, 163 pages.
Diagrams for the Significant Double Amplitudes of the Swaying, Rolling and Yawing Motions of Moored Ships in Irregular Seas, P. Wybro, L. H. Seidl, *TR-27*, J.K.K. Look Lab., Oct. 1972, 93 pages.
Comparison of the Swaying, Rolling and Yawing Response Operators Obtained from Computer Program ASYMO with Experimental and Theoretical Results, P. G. Wybro, L. H. Seidl, *TR-28*, Oct. 1972, 67 pages.

054-08120-420-60

WATER WAVE FORECASTING FOR DESIGN

(*b*) State of Hawaii.
(*c*) C. L. Bretschneider.
(*d*) Applied research in the office.
(*e*) Prediction of operational sea states and design wave conditions as an aid to the design of offshore and coastal structures.
(*g*) A method (Bretschneider 1972) for forecasting hurricane-generated water waves has been developed which is a significant improvement over "Revisions in Wave Forecasting: Deep and Shallow Water," by C. L. Bretschneider: Proc. 6th Conf. Coastal Engr., ASCE, 1958, pp. 30-67.
(*h*) **Revisions of Hurricane Designing Wave Practices,** *Proc. 13th Conf. Coastal Engr., ASCE*, July 1972.
Effects of Environmental Factors, Part 2, C. L. Bretschneider, *Intl. Symp. Discharge of Sewage from Sea Outfalls*, London, England, Aug. 27 - Sept. 3, 1974.
Relationship between the Significant Waves and the Directional Wave Spectrum, C. L. Bretschneider, S. H. Ou, F. L. W. Tang, T. T. Lee; *Intl. Symp. Ocean Wave Measurement and Analysis*, New Orleans, La., Sept. 9-11, 1974.

054-08121-420-60

MEASUREMENT OF OCEAN WAVE PARTICLE VELOCITIES

(*b*) State of Hawaii.
(*c*) R. A. Grace.
(*d*) Basic research using a measuring system based on the ocean bottom in 40 ft of water off Oahu about 3 miles NW off Waikiki.
(*e*) Determine wave-induced water particle velocities using a ducted current meter. Measure concurrent wave history with wave pressure sensor. Compare data to theoretical deterministic predictions.
(*f*) Completed.
(*g*) Linear theory found to be a good predictor.
(*h*) **Real and Theoretical Water Motion Near the Sea Floor Under Long Ocean Swells,** R. A. Grace. Reprints, *1st Australian Conf. Coastal Engrg.*, Sydney, May 1973, pp. 1-7.
Near Bottom Velocities Under Waikiki Swells, R. A. Grace, R. Y. Rocheleau, *TR-31*, J.K.K. Look Lab., Oct. 1973, 64 pages.

054-09277-420-44

PIPELINE SURVIVAL UNDER OCEAN WAVE ATTACK

(*b*) Office of Sea Grant, NOAA.
(*c*) R. A. Grace.
(*d*) Experimental, field project on the force exerted by ocean swell on a 16 inch pipeline in 30 ft of water. Applied research.
(*e*) Wave history to be measured with a staff gage. Water particle motion with a ducted current meter and pipeline forces with strain gage bridges. Data will be processed to yield force coefficients for both theoretical and real kinematics.

054-09278-520-00

DYNAMIC RESPONSES OF MOORED SHIPS DUE TO WAVE ACTION

(*c*) L. H. Seidl and T. T. Lee.
(*d*) Experimental and numerical type studies and applied research.
(*e*) Predict the dynamic responses of tankers moored at sea berth subjected to wave excitations from various headings. Ship motions in six degrees of freedom have been predicted with both physical and numerical models and the initial experiments were conducted with a 1:100 scale 39,200-ton tanker. A large model 1:100 scale for 3960,000-ton tanker has been constructed and will be used for future experiments.
(*f*) Both experimental and numerical studies are in progress.

054-09279-520-88

DYNAMIC RESPONSES OF SEA BERTH-MOORINGS-TANKER DUE TO WAVE ACTION

(*b*) Osaka City University, Osaka, Japan, and University of Hawaii.

(*c*) T. T. Lee.
(*d*) Experimental and applied research, and numerical techniques.
(*e*) Provide a method to predict dynamic response of supertankers moored at a sea-berth excited by water waves and related mooring forces and impact forces induced to berthing structures. The study involves an experimental study of a 200,000 DWT supertanker at 1:40 model scale measuring impact forces, mooring forces and ship motions as excited by beam-on waves.
(*f*) Completed during the period of February 1973-April 1975. The experiments were conducted at the Osaka City University, Osaka, Japan during June-September 1973.
(*g*) Significant results included the development of 120 response operators for impact force, mooring forces and ship motions for a particular mooring configuration. Also included are the effects of dolphin-fender stiffness on hydrodynamic mass; the effects of elastic characteristics and initial tensions of mooring lines on impact forces, mooring forces and ship motions; and, the effects of wave characteristics on these forces and motions. The experimental results have been compared with a numerical model developed by L. H. Seidl.
(*h*) **On the Determination of Impact Forces, Mooring Forces, and Motion of Supertankers at Marine Terminals,** T. T. Lee, S. Nagai, K. Oda (Osaka City University); presented *7th. Ann. Offshore Tech. Conf.*, May 5-8, 1975, Houston, Tex., 21 pages.
Dynamic Responses of Berth-Moorings-Tanker Excited by Water Waves, T. T. Lee, S. Nagai, K. Oda, presented *3rd Intl. Ocean Development Conf.*, Aug. 5-8, 1975, Tokyo, Japan, 17 pages.
Correlation Between Theoretical and Experimental Values of Motions of Ships Moored at a Sea Berth, L. H. Seidl, T. T. Lee, presented *3rd Intl. Ocean Development Conf.*, Aug. 5-8, 1975, Tokyo, Japan, 9 pages.
Offshore Terminals, T. T. Lee, L. H. Seidl, *TR-35*, J.K.K. Look Lab., Apr. 1975, 26 pages. Presented Apr. 8, 1975 meeting of Hawaii Section, Soc. Naval Arch. Marine Engrs.

054-09280-420-52

OPERATIONAL SEA STATE AND DESIGN WAVE CRITERIA FOR OCEAN THERMAL ENERGY CONVERSION PROJECTS

(*b*) Energy Research and Development Administration (ERDA) and National Science Foundation with technical monitoring by the U. S. Naval Facilities Engineering Command.
(*c*) Prof. Charles L. Bretschneider.
(*d*) Literature and archive compilation and review.
(*e*) Provide information on the wind, wave and current climate of the deep ocean in about thirty-five zones, specifically those along USA coasts of Atlantic Ocean including the Gulf of Mexico and Pacific Ocean, including the Hawaiian Islands along equator from N20° to S20° latitude. The water in these zones could have significant potential to "fuel" a power plant by the difference in temperature between the water on the bottom and the surface of the ocean.

054-09281-410-00

ON THE OPTIMUM SPACING OF GROINS IN COASTAL PROTECTION

(*c*) U. B. Nayak.
(*d*) Applied research; experimental in laboratory aided by field investigations for Doctoral thesis.
(*e*) Develop a rational method to determine the spacing of groins for effective functioning in coastal protection, as a design tool for an engineer to aid in planning of coastal protection works.

054-09282-340-54

NEARSHORE APPLICATION FOR OCEAN THERMAL ENERGY CONVERSION PILOT PLANT IN HAWAII

(*b*) National Science Foundation and Energy Research and Development Administration.
(*c*) Karl H. Bathen.
(*d*) Applied; experimental in the ocean with theoretical support; concerned with both oceanographical and socio-economic environmental impacts.
(*e*) A 13-month project which examined the potential impact of conducting proof tests in subtropical waters of the Ocean Thermal Energy Concept (OTEC) for a power plant. Hawaii was selected because the economic conditions and oceanographic conditions are amenable to such a test. The Keahole site on the island of Hawaii (Big Island) was studied including historical and oceanographic factors and those relating to the discharge of cold nutrient-laden water into the nearshore layer. Environmental analyses were made including plume predictions; surface heat exchange and alteration; downstream heat storage changes; nutrient additions; potential bio-stimulation; and estimate of extreme environmental conditions. Each of these subjects was related to State of Hawaii water quality standards. The socio-economic impact on the local area from the addition of a new power source has been studied. Legal questions were answered and socio-economic profiles of the community and input-output economic analyses were made.
(*f*) First increment completed May 1974. Additional work is underway.
(*g*) The Keahole Point site on island of Hawaii has the benefits of subtropical waters and, in addition, a nearly constant water temperature difference from surface to 600 meters of approximately 20 °C, moderate currents along the coast (0.25 to 1.5 knots), and offshore bathmetry which drops to a 600 meter depth within 1.2 kilometers of the coastline. Nutrient concentrations in the deep ocean are approximately 3 to 20 times those at the surface. Discharge from the planned 20 megawatt pilot plant would produce a plume recognizable just 200 meters from the discharge site. The cold water plume sinks rapidly and becomes stable just above the pycnocline. Dilutions reach 10 to 1 at 200 meters from the discharge site. Bio-stimulation and excess nutrients appear to be significant only in the mixing zone of the plume. Alteration of the surface heat exchange and downstream heat storage appear to be nominal and confined to 1 to 3 kilometers around Keahole Point. Socio-economic studies indicate no clear cut legal parallels for cold water discharges. Some precedent exists nationally and locally concerning licensing, permits and environmental law. Baseline studies of the Keahole area define the sociological infrastructure, local population and labor force income education and existing electric demands. Twenty megawatts additional power would influence substantially the socio-economic growth rates underway in the local community. Input and output analyses show those industries most likely impacted by a new power supply and the degree of stimulation likely to be experienced.
(*h*) **An Evaluation of Oceanographic and Socio-Economic Aspects of a Nearshore Ocean Thermal Energy Conversion Pilot Plant in an Island Environment,** K. H. Bathen, *Tech. Rept.*, Dept. Ocean Engrg., Univ. Hawaii, June 1974.

UNIVERSITY OF HAWAII AT MANOA, College of Tropical Agriculture, Department of Agricultural Engineering, 3131 Maile Way, Honolulu, Hawaii 96822. Associate Professor I-Pai Wu.

055-09025-840-00

DEVELOPMENT OF METHODS FOR OPTIMAL IRRIGATION DESIGN AND OPERATION

(*e*) Optimal design of conduit system with diverging branches, using dynamic program.

(*h*) **Design of Conduit System With Diverging Branches,** K-P. Yang, T. Liang, I-P. Wu, J. *Hydraul. Div., ASCE* **101**, HY 1, *Proc. Paper 11080*, pp. 167-188, Jan. 1975.

055-09026-840-00

TRICKLE IRRIGATION TO IMPROVE CROP PRODUCTION AND WATER MANAGEMENT

(*e*) Hydraulic analysis of lateral lines, submain and main lines of a drip irrigation system.
(*h*) **Design of Drip Irrigation Line,** I-P. Wu, H. M. Gitlin, *HAES Tech. Bull. 96*, Univ. Hawaii, 29 pages, June 1974.
Drip Irrigation Design Based on Uniformity, I-P. Wu, H. M. Gitlin, *ASAE Trans.* **17**, 3, 429-432, 1974.
Design Charts for Drip Irrigation Systems, I-P. Wu, H. M. Gitlin, *Proc. 2nd Intl. Drip Irrigation Congr.*, San Diego, Calif., pp. 305-310, July 1974.

HITTMAN ASSOCIATES, INC., Environmental and Geosciences Division, 9190 Red Branch Road, Columbia, Md. 21045. Burton C. Becker, Director.

056-08705-870-36

EVALUATION OF THE EFFECTIVENESS OF SURFACE MINE SEDIMENTATION PONDS

(*b*) U. S. Environmental Protection Agency.
(*c*) Michael A. Nawrocki, Program Manager.
(*d*) Field investigation, applied research.
(*e*) Obtain field data to determine the actual trap efficiencies of sediment ponds as compared to their theoretical and design efficiencies. Recommend design and maintenance procedures for maximum suspended solids removal.
(*g*) Project just recently started. Expect project completion to be in December 1975.

056-08706-870-10

EVALUATION OF THE PERFORMANCE OF SILT REMOVAL BASINS

(*b*) U. S. Army Corps of Engineers, Waterways Experiment Station.
(*c*) Michael A. Nawrocki, Project Engineer.
(*d*) Field investigation, applied research.
(*e*) Obtain field data to determine the actual efficiency of basins designed to remove silt-size particles from dredged slurries. Compare the field data with theoretical predictions and present design recommendations for more accurate predictions of the performance of silt removal basins. This project is a follow-on effort to a contract in which the silt removal basin concept was presented as a means of reducing the containment basin area requirements for dredging operations.
(*g*) Data indicates that the basins are more efficient in removing suspended solids than theory would predict.

056-08707-700-36

A PORTABLE DEVICE FOR MEASURING WASTEWATER FLOW IN SEWERS

(*b*) U. S. Environmental Protection Agency.
(*c*) Michael A. Nawrocki, Project Engineer.
(*d*) Experimental, basic and applied research.
(*e*) Develop a portable sewer gage for measuring flow in sewers which could be installed through a standard manhole or at an outflow. The basic concept was to measure cross-sectional area of flow in the sewer through capacitance measurements and water velocity through the timing of a heat pulse as it was propagated down a control section.
(*f*) Completed.
(*g*) Capacitance measurements can be used to measure cross-sectional area of flow with an accuracy of 5 to 15 percent. Velocity readings were accurate to within 10 percent under optimum conditions.
(*h*) **A Portable Device for Measuring Wastewater Flow in Sewers,** M. A. Nawrocki, *U. S. Environmental Protection Agency, Doc. No. EPA-600/2-73-002*, Jan. 1974, 53 pages.

HOLIFIELD NATIONAL LABORATORY, P. O. Box X, Oak Ridge, Tenn. 37830. Dr. Herman Postma, Director. (Formerly Oak Ridge National Laboratory.)

057-08215-130-00

MASS TRANSFER BETWEEN SMALL BUBBLES AND LIQUIDS IN CONCURRENT TURBULENT PIPELINE FLOW

(*c*) Dr. T. S. Kress.
(*d*) Theoretical and experimental; applied research for Doctoral dissertation.
(*e*) Studies are being made of small helium bubbles circulating in pipelines with different mixtures of glycerol and water flowing turbulently. Mass-transfer coefficients between the bubbles and the liquids are being established as functions of Reynolds number, Schmidt number, bubble size, pipe size, and gravitational orientation of the flow. Also determined are bubble size distributions, volume fractions, and surface areas. The application is to the Molten Salt Breeder Reactor in which it is proposed to extract the fission product xenon-135 by circulating small helium bubbles with the liquid fuel. By reducing the concentration of this neutron poison, a significant increase in the breeding ratio can be obtained.
(*f*) Completed.
(*g*) Turbulent flow mass transfer Sherwood numbers have been correlated with Reynolds number and bubble mean size for five different Schmidt numbers in both horizontal and vertical flows. It was found that vertical flow mass-transfer coefficients are the same as those for horizontal flow only above certain pipe Reynolds numbers where turbulent inertial forces dominate over gravitational forces. These values of Reynolds numbers marking this equivalence were found to be predictable at a particular value of a newly introduced turbulence Froude number. At lower values of this Froude number, vertical flow coefficients approach asymptotes characteristic of the bubbles rising through a quiescent liquid. In horizontal flows, the bubbles eventually stratify making further operation at lower Froude numbers impractical. The influence of Reynolds number (turbulent energy dissipation) on the Sherwood numbers was found to be different than was expected when compared on an equivalent power dissipation basis with data from agitated vessels. This was attributable to greater gravitational influence in the agitated vessels.
(*h*) **Mass Transfer Between Small Bubbles and Liquids in Concurrent Turbulent Pipeline Flow,** T. S. Kress, *USAEC Rept. ORNL-TM-3718 (Thesis)*, Oak Ridge Natl. Lab., Dec. 1971.
Liquid-Phase Controlled Mass Transfer in Concurrent Turbulent Pipeline Flow, T. S. Kress, J. J. Keyes, Jr., *Chem. Engr. Science* **28**, 1809-1823, 1973.

057-09266-870-36

EFFECTS OF CROSS FLOW ON FILTRATION OF SEWAGE

(*b*) Environmental Protection Agency and ERDA.
(*c*) James S. Johnson, Jr.
(*d*) Experimental and field investigation; applied research.
(*e*) Over the past several years, in a mobile test unit at the Oak Ridge East Municipal Sewage Plant, and more recently, in a several thousand gallons/day pilot plant at the ORNL sewage treatment facility, filtration with cross-flow by the filtering surface of the solution being filtered has been under investigation with municipal sewage (usually the effluent from primary settling) that has been treated with physical-chemical additives. Purpose of cross-flow is to slow buildup of flux-limiting filtercake; the objective is to obtain the bulk of the water, at least 95 percent, as filtrate and a slurry concentrated in impurities to

be recycled back to the primary settler or otherwise treated. Several types of filters have been used, fire-hose jackets (woven 1 to 3 in. diameter tubes) receiving predominant attention. Operating pressures investigated range from 5 to about 100 psi.

(*f*) Experimental work being concluded and final report in preparation.

(*g*) Filtrate compares favorably with biological secondary effluent, with some tertiary treatment, and is superior to most physical-chemical secondary treatments that utilize settling. With Fe(III) or Al(III) additives, filtrate has approximate turbidity of Oak Ridge drinking water (<1 JTU), 10 to 15 ppm total organic carbon, <1 ppm of phosphate, and usually few, if any, bacteria. Presence of the additive also increases flux greatly over that with untreated primary effluent and some over that of water with added ferric salt. With powdered activated carbon, quality is similar, except that little phosphate is removed, and TOC is usually about 5 ppm. Increasing cross-flow velocity increases production rate, typical average values at 15 ft/sec being 150 gpd/ft^2 with Fe(III)-treated sewage with 24-hr regeneration intervals, by backwash or otherwise; fluxes are higher with sufficient added PAC, but the level required probably necessitates carbon regeneration. After short-term transients, flux is not very sensitive to operating pressure nor, at least up to 90 percent, water recovery. Economics of tradeoff between circulation velocity and flux depends on electricity costs.

UNIVERSITY OF IDAHO, College of Engineering, Moscow, Idaho 83843. Robert R. Furgason, Dean.

058-0270W-840-07

FLOW INTO DRAINAGE FACILITIES

(*e*) For summary, see Water Resources Research Catalog **8**, 2.0537.

058-0271W-070-07

TWO AND THREE-DIMENSIONAL DIFFUSION ANALYSIS OF UNSTEADY FLOW INTO POROUS MEDIA

(*e*) For summary, see Water Resources Research Catalog **8**, 2.0538.

058-0272W-810-33

TECHNIQUES FOR DETERMINING AMOUNT AND DISTRIBUTION OF PRECIPITATION IN MOUNTAIN VALLEYS IN IDAHO

(*e*) For summary, see Water Resources Research Catalog **8**, 2.0544.

058-0273W-880-33

DEVELOPMENT OF METHODOLOGY FOR EVALUATION OF WILD AND SCENIC RIVERS IN IDAHO

(*e*) For summary, see Water Resources Research Catalog **8**, 6.0428.

058-0274W-820-00

APPLICATION OF A SIMULATION MODEL TO THE SNAKE PLAIN AQUIFER

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0483.

058-0275W-810-07

RAINFALL AND SNOWMELT RUNOFF FROM INTERMEDIATE ELEVATION WATERSHEDS

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0485.

058-0276W-820-00

PROBLEMS CONCERNED WITH LOCATION, CONSTRUCTION AND DEVELOPMENT OF A MAJOR UNDERGROUND RESERVOIR IN IDAHO

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0486.

058-0277W-150-54

DESORPTION OF SUPERSATURATED GASES FROM WATER

(*e*) For summary, see Water Resources Research Catalog **9**, 5.0548.

058-0278W-800-00

DEVELOPMENT OF A WATER RECREATION CLASSIFICATION SYSTEM AND RELATED RECREATIONAL CARRYING CAPACITIES

(*e*) For summary, see Water Resources Research Catalog **9**, 6.0313.

058-0279W-840-82

ANALYSIS AND DESIGN OF SETTLING BASINS FOR IRRIGATION RETURN FLOW

(*e*) For summary, see Water Resources Research Catalog **9**, 8.0175.

058-08957-310-33

ANTECEDENT WEATHER CONDITIONS CAUSING FROZEN GROUND FLOODS IN THE PACIFIC NORTHWEST

(*b*) Office of Water Resources and Technology, National Oceanic and Atmospheric Agency, Agricultural Research Service, Idaho Agricultural Experiment Station.

(*c*) Assoc. Professor M. Molnau and Professor G. Bloomsburg, Department of Agricultural Engineering.

(*d*) Theoretical; applied.

(*e*) At the present time, those persons charged with designing flood damage prevention works and flood forecasting do not have an adequate method for assessing the probable occurrence of frozen ground and its influence on the flood duration, volume, or peaks. The purpose of this study is to identify the important hydrologic, meteorologic and soil parameters that could be useful in a predictive flood forecasting technique for frozen ground floods in the Pacific Northwest.

058-08958-840-33

REHABILITATION OF IRRIGATION WATER MANAGEMENT SYSTEMS IN EASTERN IDAHO

(*b*) Idaho Agricultural Experiment Station, Office of Water Resources and Technology.

(*c*) Asst. Professor J. R. Busch, Department of Agricultural Engineering.

(*d*) Field investigation; applied.

(*e*) Water use efficiencies in many of the older, gravity-irrigated areas in Idaho are quite low in comparison to those attainable. The objectives of this project are to develop procedures for determining how to rehabilitate an irrigated area in order to obtain a specified water use efficiency; and to determine the impact of large scale improvement of water management practices on the economic and social aspects of an area. As a part of this study, methodology for obtaining least cost irrigation system specifications is being developed.

058-08959-840-10

CONTROL OF LOSSES OF SEDIMENT AND OTHER POLLUTANTS FROM IRRIGATED LANDS

(*b*) Idaho Agricultural Experiment Station, U. S. Army Corps of Engineers, Environmental Protection Agency.

(*c*) Professor D. Fitzsimmons, Asst. Professor J. R. Busch, Department of Agricultural Engineering, and Assoc. Research Professor C. Brockway, Department of Civil Engineering.
(*d*) Experimental; applied.
(*e*) Determine the effectiveness and economic impacts of alternative measures for controlling the loss of sediment, nutrients and other pollutants from irrigated areas. The investigators are faced with determining how best to achieve the degree of pollutant discharge control required under proposed discharge permit systems for irrigation return flow.

058-08960-860-13

EFFECTS OF WATER MANAGEMENT PRACTICES ON WATER QUALITY IN THE BOISE VALLEY

(*b*) U. S. Corps of Engineers, Walla Walla District.
(*c*) Professor D. Fitzsimmons, Department of Agricultural Engineering.
(*d*) Field investigation; applied.
(*e*) Quantitative data on sediment and nutrient losses from irrigated farms in the Boise Valley will be obtained. These data will be used to develop criteria which can be used to evaluate water management practices with respect to costs and effectiveness in controlling sediment and nutrient losses.

058-08961-800-33

PHYSICAL AND DECISION MAKING ALTERNATIVES FOR FLOW REGULATION AND USE OF THE SNAKE RIVER THROUGH HELLS CANYON – A PROPOSED RECREATION AREA

(*b*) Office of Water Resources Research.
(*c*) Professor C. Warnick, Department of Civil Engineering.
(*d*) Theoretical; applied.
(*e*) A study of hypothetical upstream depletions of the Snake River above Hells Canyon will be made as to timing and reaches of the river. This will be followed by a brief assessment of the impact such use and depletion would have on uses downstream of Hells Canyon Dam of the Snake River. The analysis will concentrate on strategies and methodology for making assessment of changes in river flow. Functions that might be influenced by the changes in river flow are power production, tourist use, navigational service, water quality, and sustenance and enhancement of anadronomous fish runs.

058-08962-870-33

SEDIMENT IN STREAMS AND EFFECT ON AQUATIC BIOTA

(*b*) Office of Water Resources Research.
(*c*) Professor F. J. Watts, Department of Civil Engineering.
(*d*) Experimental, field investigation; applied.
(*e*) This study, begun in 1972, was undertaken to assess the impact of sedimentation on aquatic insects and fish inhabiting streams of the Idaho Batholith area. A brief report highlighting the findings of the researchers was released in December 1974. Their work is continuing under a second grant from the Office of Water Research and Technology and is scheduled for completion in 1976.
(*f*) To be completed in 1976.

058-08963-880-10

ECOLOGICAL RESILIENCY

(*b*) U. S. Army Corps of Engineers.
(*c*) Professor D. F. Haber, Department of Civil Engineering.
(*d*) Theoretical; applied.
(*e*) Environmental systems are usually quite flexible and can adapt readily to minor perturbations. As long as these outside influences are not too great, the system (a fish population in a given area is one example) remains fairly stable. If the system is pushed too far from its normal equilibrium point,a new equilibrium is sometimes established, and the system does not recover to its former state. The object of the work is to provide the Corps with a simulation model that will assist them in determining if some planned action, like construction of a dam, will push the eco-system so far from its normal state that new equilibriums are established.

058-08964-860-60

ALTERNATIVE STORAGE OPERATIONS ON PRIEST LAKE

(*b*) Idaho Department of Water Resources, Idaho Engineering Experiment Station.
(*c*) Asst. Professor J. H. Milligan, Department of Civil Engineering.
(*d*) Theoretical; applied.
(*e*) In this study, several alternative water release operations of Priest Lake Outlet Dam are evaluated and compared with the present operation. Relevant considerations to be included in the evaluations are flood damage reduction, power production, lake recreation, river recreation, regional income, and environmental quality.

058-08965-870-60

NUCLEAR AND GEOTHERMAL POWER PLANT SITING AS RELATED TO WATER RESOURCES IN IDAHO

(*b*) Idaho Nuclear Energy Commission.
(*c*) Professor C. Warnick and Assoc. Research Professor C. Brockway, Department of Civil Engineering.
(*d*) Theoretical; applied; M.S. thesis.
(*e*) The Idaho Nuclear Energy Commission has requested that a comprehensive plan be developed for locating energy production and related facilities within Idaho. Potential sites and plant sizes are to be evaluated in relation to water availability and method of disposal of the heated waste waters. Other considerations will include legal problems, acquisition of water and related lands, and groundwater effects.
(*f*) Completed.

058-08966-810-60

BOISE HYDROLOGY

(*b*) Idaho Water Resources Board.
(*c*) Professor C. Warnick, Assoc. Research Professor C. Brockway, Department of Civil Engineering.
(*d*) Field investigation; applied.
(*e*) A study of water use and water control of the Boise River project as a part of a case study of Federal expenditures on a water development project. Includes study of hydrologic system, reservoir system, irrigation system, the water rights, floods and flood control, and groundwater of the Boise River basin.

058-08967-840-33

IMPACT OF CHANGES IN IRRIGATION WATER USE IN THE UPPER SNAKE RIVER BASIN

(*b*) Office of Water Resources Research.
(*c*) Assoc. Research Professor C. Brockway, Department of Civil Engineering.
(*d*) Field investigation, theoretical; applied, M.S. thesis.
(*e*) This three year study was undertaken in 1972 to determine water use patterns and efficiency on irrigation distribution systems in the Upper Snake River Basin and to propose reasonable changes in water use practices to improve irrigation district efficiency. Typical water use and distribution systems are being evaluated by determining water budgets including river diversions, surface return flow and crop evapotranspiration. The hydraulic efficiency of distribution systems are also being analyzed and the areas where increases in efficiency can be achieved will be cataloged. Estimated potential changes in water use for selected districts will be applied to each subarea of the basin and regional effects evaluated using river and aquifer models.
(*f*) Completed.

058-08968-820-33

REGIONAL RESEARCH ON PROBLEMS CONCERNED WITH BASALT AQUIFERS OF THE PACIFIC NORTHWEST

(*b*) Office of Water Resources Research.
(*c*) Professor C. Warnick, Assoc. Research Professor C. Brockway, Professor J. S. Gladwell, Department of Civil Engineering, and E. W. Trihey, Asst. Director, Water Resources Research Institute.
(*e*) This study was an evaluation of research needs in the Pacific Northwest with regard to groundwater. This was a systematic attempt to define what are the most urgent problems concerned with basalt groundwater aquifers. The study entailed several meetings with personnel of agencies concerned.
(*f*) Completed.

058-08969-800-33

CLASSIFICATION CRITERIA FOR WILD AND SCENIC RIVERS

(*b*) Office of Water Resources and Technology.
(*c*) Asst. Professor J. H. Milligan, Department of Civil Engineering.
(*d*) Theoretical; applied.
(*e*) Develop criteria for determining whether or not a given river should be designated as a wild and scenic river. Engineering input consists of hydrologic investigations relative to establishing the river classification criteria. This study, which is using a portion of the Priest River as a test case, is being jointly conducted by the Departments of Civil Engineering, Agricultural Economics, and Sociology.

058-08970-820-13

EVALUATION OF GROUNDWATER QUALITY EFFECTS DUE TO FEEDLOTS AND LAND DISPOSAL SYSTEMS IN THE BOISE VALLEY AREA

(*b*) U. S. Corps of Engineers, Walla Walla District, Idaho Agricultural Experiment Station, Idaho Engineering Experiment Station.
(*c*) Asst. Professor J. H. Milligan, Department of Civil Engineering.
(*d*) Experimental, field investigation; applied.
(*e*) Evaluations are made of the effects on groundwater quality due to cattle feedlots and associated manure disposal systems. Objective is to provide planning and operation guidelines for owners and operators, regulatory agencies and land-use planners.

058-08971-870-82

DEEP TANK AERATION

(*b*) Northwest Pulp and Paper Association.
(*c*) Professor M. L. Jackson, Department of Chemical Engineering.
(*d*) Theoretical, experimental; basic, applied; M.S./Ph.D. thesis.
(*e*) The use of tall columns for aerated biological waste treatment is advantageous due to the more efficient use of oxygen which is pumped in at the bottom of the column. The oxygen transfer rate into the liquid is higher at the increased pressure and the rise time, and therefore the contact time, is longer. The present work will involve a study of the oxygen transfer process to water and to sulfite solutions to simulate biological waste treatment. A scale-up procedure will be formulated to interpret 75 ft column aeration data as developed in the Chemical Engineering laboratories at the University of Idaho and a much larger tank at the Inland Empire Paper Company in Spokane. The treatment method is potentially applicable for many other industrial and municipal waste problems in Idaho.

058-08972-870-33

SEDIMENT IN STREAMS AND ITS EFFECTS ON AQUATIC BIOTA

(*b*) Office of Water Resources Research.
(*c*) Asst. Professor J. H. Milligan, Department of Civil Engineering.
(*d*) Experimental, field investigation; applied.
(*e*) Much of the Salmon and Clearwater River drainages in Idaho are in the Central Idaho Batholith. The steep slopes and granitic base rock of the batholith are unstable and easily eroded. Watershed disturbances such as road building and logging can lead to extreme sedimentation of the streams. The extent and duration of impact on aquatic insects and fish has not been quantitatively measured. Predictions of sediment damage to aquatic resources are needed by resource managers to adequately plan for the use and protection of all resources in the Batholith. Laboratory channels with natural fish and insect populations will be subjected to various flows and amounts of sediment, changes in the aquatic habitat, abundance and behavior of fish and insects, and sediment transport will be measured. Natural streams with adequate fish and insect populations will be observed and sediment added to assess changes in habitat, fish and insect abundance and behavior. Observations in natural and laboratory channels will be compared.

IIT RESEARCH INSTITUTE, Engineering Mechanics Division, 10 West 35th Street, Chicago, Ill. 60616. Dr. K. E. McKee, Director.

059-09594-880-70

ENVIRONMENTAL NOISE FROM PROCESSING PLANT

(*b*) Industrial.
(*c*) Dr. R. S. Norman.
(*d*) Experimental field evaluation.
(*e*) Reduce the environmental noise from a large, processing plant. A major noise source was generated in several high pressure (up to 1000 psi), liquid flow pipes. An orifice was used to reduce system pressures for by-pass flows. High amplitude, discrete tones were generated at these single-hole orifices.
(*g*) Multiple-hole orifices were used by the client to reduce discrete tones substantially.

ILLINOIS INSTITUTE OF TECHNOLOGY, Department of Mechanics, Mechanical and Aerospace Engineering, 3110 South State Street, Chicago, Ill. 60616. Sudhir Kumar, Department Chairman.

061-09336-340-54

OPEN-CIRCULATING-WATER COOLING SYSTEMS FOR LARGE ELECTRIC POWER PLANTS

(*b*) National Science Foundation – RANN.
(*c*) Dr. R. W. Porter, Associate Professor.
(*d*) Theoretical (analytical and numerical), experimental (laboratory) and field investigation; basic and applied research, Master's, Doctoral and Post Doctoral.
(*e*) To determine controlling fluid mechanic and heat-and-mass transfer phenomena of managing waste heat from condensor cooling systems via spray canals. Emphasis is on air-vapor flow as related to the canal, spray modules and entire system including buoyant wake. Improvement of thermal models and their coupling with other systems is also included.
(*g*) Numerical (first reference) and simplified analytical (second reference) thermal analyses have been developed and evaluated using previous field tests.
(*h*) **Heat and Mass Transfer of Spray Canals,** R. W. Porter, K. H. Chen, *J. Heat Transfer* **96**, pp. 286-291, Aug. 1974.
Analytical Solution for Spray-Canal Heat and Mass Transfer, *AIAA Paper 74-764*, *ASME Paper 74-HT-58* (Joint), July 1974.

061-09337-880-54

MICROCLIMATE OF BUILDINGS AND URBAN AREAS – ITS NATURE AND CONTROL

(*b*) National Science Foundation.
(*c*) Professors A. A. Fejer, M. V. Morkovin, H. M. Nagib.
(*d*) Experimental; basic and applied research, Master's and Doctoral Theses.
(*e*) Interactions between natural winds and buildings often produce local wind conditions on plazas and surrounding streets that are much more severe than the undisturbed wind above these areas. This National Science Foundation grant provides funds for the development of techniques to simulate such wind-induced conditions in the IIT environmental wind tunnel and for conducting systematic studies to clarify the characteristics of these complex patterns of flow and the factors controlling them. The resulting understanding may lead to building design modifications and improvements in artificial ground-level barriers that brake the violence of wind patterns.
(*g*) See titles of references listed under (h).
(*h*) **Effect of Wind Breaks on Flows on Plazas and Around Buildings,** A. A. Fejer, P. A. Dauzvardis, *Proc. 2nd U. S. Natl. Conf. Wind Engrg. Research*, Colo. State Univ., June 1975.
Sensitivity of Flow Near a Building to Changes in Surface Layer - A Study Using the I.I.T. Counter-Jet Technique, H. M. Nagib, T. C. Corke, J. Tan-atichat, *Proc. 2nd U. S. Natl. Conf. Wind Engrg. Research*, Colo. State Univ., June 1975.
Wind Tunnel Simulation of Neutral Atmospheric Surface Layers by the Counter-Jet Technique, J. Tan-atichat, H. M. Nagib, *Proc. 67th Ann. Mtg. Air Pollution Control Assoc.*, Denver, Colo., 1974, *Paper No. 74-214*. To appear *J. APCA*.
On Modeling of Atmospheric Surface Layers by the Counter-Jet Technique, H. M. Nagib, M. V. Morkovin, J. T. Yung, J. Tan-atichat, *AIAA 8th Aerodynamics Testing Conf.*, Bethesda, Md., July 1974, *Paper No. 74-638*. To appear *AIAA J.*
Flow Near a Model of a Building in Simulated Atmospheric Surface Layers Generated by the Counter-Jet Technique, *Proc. 4th Intl. Conf. Wind Effects on Buildings and Structures*, Sept. 1975, London, England.

ILLINOIS STATE WATER SURVEY, Box 232, Urbana, Ill. 61801. William C. Ackermann, Chief. (A list of publications is available upon request from Illinois State Water Survey.)

062-07331-860-65

HYDRAULICS OF WATER TREATMENT PLANTS

(*b*) Chicago Water Filtration Plant.
(*c*) Mr. H. W. Humphreys.
(*d*) Experimental; applied research.
(*e*) Improve the flow conditions in the various components of a water treatment plant. The first project is a model study to improve the flow conditions in a settling basin. Model modifications will be made, the flow conditions observed, and velocity distributions measured to determine which modification is desirable to improve the flow conditions.
(*f*) Completed.
(*g*) Presented as an open file report listed as Report of Investigation 77.

UNIVERSITY OF ILLINOIS AT CHICAGO CIRCLE, Department of Energy Engineering, College of Engineering, Box 4348, Chicago, Ill. 60680. Paul M. Chung, Acting Head.

063-09064-020-00

TURBULENCE DESCRIPTION OF COUETTE FLOW

(*e*) The simplified statistical theory developed earlier is extended to the wall shear flows. This is accomplished by formulating the contribution of the smaller eddies to the observable properties, which becomes significant very close to the wall, from an available stochastic analysis of the Navier-Stokes equation. Turbulent Couette flow is then analyzed by the use of the theory. Comparison of the Couette flow solutions obtained with the available experimental results shows that the present theory satisfactorily describes the rather detailed turbulence structure of the flow field as well as the mean velocity profile and the surface shear.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, Colleges of Agriculture and Engineering, Department of Agricultural Engineering, Urbana, Ill. 61801. Frank B. Lanham, Department Chairman.

064-08024-820-07

NITROGEN AS AN ENVIRONMENTAL QUALITY FACTOR – DETERMINING AND MODELING THE VARIOUS STEPS OF THE N CYCLE

(*b*) USDA - CSRS, Illinois; Rockefeller Foundation.
(*c*) Dr. W. D. Lembke.
(*d*) Field and laboratory investigation; basic research.
(*e*) See WRRC **9**, 5.0615.
(*g*) A surface water study of nitrogen in 10 ponds in Washington County, Ill., was completed with an M.S. thesis in 1974. Ponds having substantial amounts of manure applied to the watershed showed a poorer water quality than ponds with watersheds having fertilizer applied alone. A unique method was developed for measuring denitrification. Gas released near the bottom of ponds was collected and analyzed using a gas chromatograph, thus providing a measure of the denitrification process. This analysis revealed that a large amount of nitrogen entering ponds via runoff was converted to nitrogen gas.
The quality of runoff and percolate from a rainfall event on soil which had received various applications of treated liquid waste was the subject of a Masters thesis completed in 1974. In this study aerobically treated liquid swine waste was applied to small plots of soil, allowed to dry, and subjected to artificial rainfall. The runoff and percolate were collected and analyzed in order to study the effects of waste applications on water quality and soil erosion. A revised soil erodibility factor and a manure erodibility factor were developed for use in the universal soil loss equation.
Two new areas of research were initiated in 1974. First, an investigation was begun on the effectiveness of certain feedlot runoff control systems in Illinois. Five livestock enterprises are under study to measure the quality of water being returned to streams and the fertilizer value of the nitrogen returned to the land. Secondly, a study of the fate of nitrogen under four different fertility programs was begun for sandy soil. The fertility programs being studied are a low level of chemical fertilizer; a high level of chemical fertilizer; secondary sludge from a municipal waste treatment plant; and dry manure from a beef feedlot.
(*h*) **Water Quality and Soil Erosion From Surface Application of Treated Liquid Swine Waste,** R. W. Gunther. Unpublished *M.S. Thesis*, Library, Univ. Ill. at Urbana-Champaign, June 1974.

Pond Water Quality and Water Use for Small Agricultural Watersheds in Southern Illinois, E. C. Dickey. Unpublished *M.S. Thesis*, Library, Univ. Ill. at Urbana-Champaign, June 1974.
Sampling Pond Water Without a Boat, E. C. Dickey, J. K. Mitchell, *Illinois Research* **15,** 1, pp. 18-19, 1973.
Device for Obtaining Water Samples from Small Ponds or Lagoons, J. K. Mitchell, E. C. Dickey. *Trans. ASAE* **16,** pp. 544-545, 1973.

064-08681-810-07

RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

(*b*) U. S. Dept. Agriculture.
(*c*) Dr. J. Kent Mitchell.
(*e*) See WRRC **9,** 2.0497.
(*g*) All of the rainfall and runoff data from the Allerton watersheds for 1973 have been reduced, tabulated and assembled for analysis. The temperature-humidity data have been transcribed from the charts to 1970.
The 1973 rainfall-runoff data showed considerable periods of above normal rainfall and runoff. The total rainfall for 1973 was 49.09 inches which was nearly the same as the 49.19 inches recorded at the Urbana station and is 15.97 inches greater than the long-term average collected at the watersheds. Most of the above normal rainfall occurred in March (8.99 inches), June (9.28 inches) and July (6.86 inches). In March and June there were four rainfall events greater than one inch and one event greater than two inches; the June event being 3.35 inches. In July there was only one event greater than one inch and that was one of 5.34 inches of rainfall. However, the greatest intensity recorded for 1973 was 7.04 iph for 4 minutes during a storm in November.
Runoff events were also quite numerous with 2.67 and 5.30 inches of runoff recorded from Watersheds A1 and B1, respectively, for the year. The greatest runoff amounts for A1 occurred in June and July, while for B1 the largest amounts were recorded in March, April, and June. The maximum runoff rate occurred during the same storm in June for both watersheds; 116.75 cfs (1.41 iph) for A1 and 55.57 cfs (1.21 iph) for B1.
The difference in monthly occurrences during 1973 is partly explained by the cropping pattern. Most of Watershed B1 was plowed early and planted to corn. Most of Watershed A1 was in corn the previous year, the stubble providing protection until tillage just before soybean planting in early June.
(*h*) **Clodhopper Helps with Soil Studies,** J. K. Mitchell, B. A. Jones, Jr., *Ill. Res.* **13,** 4, pp. 10-11, 1971.

064-08682-820-00

HYDRAULIC AND HYDROLOGIC MODELS OF COMPONENTS OF SOIL AND WATER CONTROL SYSTEMS

(*c*) Dr. W. D. Lembke.
(*e*) See WRRC **9,** 2.0498.
(*g*) A mathematical simulation model has been developed to predict field working days in the spring. The model utilizes climate, soils, drainage and surface trash data. It has been tested with crop reporting service data for two soils in Central Illinois and has been found to be particularly useful in establishing a value, in terms of field working days, for drainage system improvements.
A two-year study on the evaluation of installed 5-, 6- and 8-inch corrugated plastic drain tubing was initiated on September 1. Eighty sites with tubing installed under a variety of conditions will be selected. Since vertical deflection is an indicator of durability, an electronic device is in the process of development which will be used to measure vertical deflection occurring over forty to fifty feet of buried tubing. Results will be evaluated with regard to soil type, period of time that the tubing has been installed, method of blinding, method of backfilling, stretch of the tubing that occurred during installation, size of trench-bottom groove, and strength of tubing as measured in the laboratory.
(*h*) **A Simulation Model for Predicting Available Days for Tillage,** R. L. Elliott. Unpublished *M.S. Thesis*, Library, Univ. Ill. at Urbana-Champaign, Oct. 1974.

UNIVERSITY OF ILLINOIS, Department of Chemical Engineering, Urbana, Ill. 61801. Professor Thomas J. Hanratty.

065-08683-020-54

STRUCTURE OF TURBULENCE CLOSE TO A WALL

(*b*) National Science Foundation.
(*d*) Experimental and theoretical; basic research; Ph.D. theses.
(*e*) Electrochemical techniques are used to study fluctuating wall shear stress, fluctuating mass transfer rates, fluctuating concentrations, and fluctuating velocities. The systems are pipes of 1-in. and 8-in. diameter.
(*g*) New information about the viscous sublayer, drag reduction and turbulent mass transfer.
(*h*) **Identification of Turbulent Wall Eddies Through the Phase Relation of the Components of the Fluctuating Velocity Gradient,** *J. Fluid Mech.* **66,** 1, 1974.

065-08684-250-80

DRAG REDUCTION

(*b*) Petroleum Research.
(*d*) Experimental and theoretical; basic research; Ph.D. theses.
(*e*) The influence of drag-reducing polymers on the structure of turbulence is being studied.
(*f*) Drag-reduction has been associated with the wave length of flow oriented eddies.
(*h*) **The Influence of Drag-Reducing Polymers on Turbulence in the Viscous Sub-Layer,** *J. Fluid Mech.* **53,** p. 575, 1972.

065-08685-000-54

FLOW OVER SOLID WAVES

(*b*) National Science Foundation.
(*d*) Experimental; basic research; Ph.D. theses.
(*e*) The variation shear stress and mass transfer rate along wavy surfaces is being measured.
(*f*) Wavelike dissolution patterns on the underside of ice and inside caves has been explained.
(*h*) **Transport Phenomena Associated with Flow Over a Solid Wavy Surface,** *Ph.D. Thesis*, C. B. Thorsness, 1974.

UNIVERSITY OF ILLINOIS, Hydrosystems Laboratory, Department of Civil Engineering, Urbana, Ill. 61801. Professor V. T. Chow.

066-07337-810-54

HYDRODYNAMICS OF WATERSHED FLOW

(*b*) National Science Foundation.
(*d*) Theoretical and experimental; applied research.
(*e*) To apply the mathematical models developed in a previous National Science Foundation project on mechanics of surface runoff, with the experimental verification by the University of Illinois Watershed Experimentation System (WES), to practical problems such as flood control and urban drainage in the field of watershed hydraulics. The models are Illinois Hydrodynamic Watershed Models II and III, IV, and V. A comprehensive systematic laboratory experimental program to test these models was conducted.
(*f*) Completed.
(*g*) Four hydrodynamic watershed models have been developed.

(*h*) **Formulation of Mathematical Watershed-Flow Model,** C. L. Chen, V. T. Chow, *Trans. ASCE* **137,** 1972, pp. 267-268.
The Illinois Hydrodynamic Watershed Model III (IHW Model III), V. T. Chow, A. Ben-Zvi, Civil Engrg. Studies, *Hydraulic Engrg. Ser. No. 26*, Univ. Ill., Sept. 1973, 47 pages.
Hydrodynamic Modeling of Two-Dimensional Watershed Flow, *J. Hydraul. Div., ASCE* **99,** HY11, Nov. 1973, pp. 2023-2040.
A Constant Discharge Siphon for Flow Measurement and Control, B. C. Yen, V. T. Chow, *Proc. Koblenz Symp.* **1,** W. Germany, UNESCO-WMO-IASH, 1973, pp. 444-452.

066-07338-800-33

ADVANCED METHODOLOGIES FOR WATER RESOURCES PLANNING

(*b*) Office of Water Resources Research.
(*d*) Theoretical; applied research.
(*e*) Investigate advanced techniques of water resources planning which have not been generally introduced into practice. These techniques include mainly various methods of operations research such as stochastic analysis and dynamic programming. In the investigation mathematical models are formulated for computer analysis and actual river basin data are tested in working procedures to be developed. The procedure of investigation consists of three steps: (1) to critically examine the feasibility of the concepts of stochastic hydrology and various optimization techniques, (2) to formulate hydroeconomic system models for analysis by stochastic optimization techniques, and (3) to develop working procedures using optimization techniques for application to practical water resources planning. During the year a farm irrigation system model has been developed.
(*f*) Completed.
(*g*) A practical manual illustrating the practical applications of the proposed methodologies was prepared.
(*h*) **Application of DDDP in Water Resources Planning,** V. T. Chow, G. Cortes-Rivera, Water Resources Center, *UILU-WRC-74-0078, Res. Rept. No. 78*, Univ. Ill. at Urbana-Champaign, Urbana, Ill., Jan 1974, 89 pages.

066-07339-810-33

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS

(*b*) Office of Water Resources Research.
(*d*) Theoretical; applied research.
(*e*) Develop a practical procedure by which the stochastic behavior of a hydrologic system can be adequately simulated. In the study a watershed is treated as the stochastic hydrologic system whose components are simulated by time series models. Emphasis is given to application of the procedure to the planning of rural and urban watersheds in Illinois.
(*h*) **Analysis of Residual Hydrologic Stochastic Processes,** S. J. Kareliotis, V. T. Chow, *J. Hydrology* **15,** 2, Feb. 1972, pp. 113-130.
Theory of Stochastic Modeling of Watershed Systems, V. T. Chow, T. Prasad, *J. Hydrology* **15,** 4, Apr. 1972, pp. 261-284.
Analysis of Multiple-Input Stochastic Hydrologic Systems, *Res. Rept. No. 67*, Water Resources Center, Univ. Ill. at Urbana-Champaign, Urbana, Ill., July 1973, 66 pages.

066-07340-310-00

EVALUATION OF FLOOD RISKS

(*d*) Theoretical; applied research.
(*e*) Flood data at ten stream gaging stations on rivers in Illinois are analyzed for their characteristics of flood generation on the basis of the theory of nonparametric probability distributions. Once the probability model for flood occurrences is formulated, flood sequences are generated by the Monte Carlo method and then compared with historical flood sequences.

066-08026-710-54

TRACER MIXING FOR DISCHARGE MEASUREMENTS IN PIPES

(*b*) National Science Foundation.
(*c*) Professor E. R. Holley.
(*d*) Theoretical; experimental; applied research.
(*e*) The use of a turbulent jet located at the pipe wall as a tracer source in discharge measurements in pipes was studied experimentally and analytically. A mathematical model was developed to predict the behavior of the tracer injected as a buoyant or nonbuoyant jet. The reduction in the mixing distance warrants the use of a jet as a tracer source. The range of jet and pipe flow characteristics investigated is directly applicable to field use.

066-08027-700-33

DEVELOPMENT OF A DEVICE FOR DISCHARGE MEASUREMENT WITHIN A SEWER PIPE

(*b*) Office of Water Resources Research.
(*c*) Professor H. G. Wenzel.
(*d*) Experimental; applied research.
(*e*) Develop a device which is capable of measuring unsteady discharge within a sewer pipe under both open-channel and full-flow conditions. Analytical studies will be carried out to determine the optimum geometry and theoretical rating curves. These results will then be investigated experimentally. Characteristics such as head loss, backwater effects, and reduction in sewer capacity will be studied. Actual rating curves will be developed using various pipe sizes and final recommendations for design presented.
(*h*) **Meter for Sewer Flow Measurement,** H. G. Wenzel, Jr., *J. Hydraul. Div., ASCE* **101,** HY1, Jan. 1974, pp. 115-133.
Development of a Meter for Measurement of Sewer Flow, H. G. Wenzel, *Water Resources Center Res. Rept. No. 74*, Univ. Ill., Nov. 1973.

066-08030-860-00

OPTIMAL OPERATION OF RESERVOIRS

(*d*) Theoretical; applied research.
(*e*) Operations research techniques are used to optimize the operation of a system of reservoirs. The procedure so developed is used to determine operating policies for existing reservoir systems or for potential system designs in connection with simulation studies. An actual flood control system located in the Upper Wabash River Basin in Indiana is used as an illustrative example.
(*h*) **Multireservoir Optimization Model,** J. S. Windsor, V. T. Chow, *J. Hydraul. Div., ASCE* **98,** HY10, Oct. 1972, pp. 1827-1845.
Multireservoir Optimization Model, J. S. Windsor, V. T. Chow, *Trans. ASCE* **138,** 1973, pp. 532-533.

066-08031-800-33

ADVANCED METHODOLOGIES FOR WATER RESOURCES PLANNING – PHASE II

(*b*) Office of Water Resources Research.
(*d*) Theoretical; applied research.
(*e*) Refine the new methodologies that have been developed in Phase I of the research program, to develop additional new water resources planning tools, and to perform sensitivity tests for proposed or existing water resources projects by means of the new planning tools so developed in order to examine the system responses due to hydrologic, economic urban and other factors affecting water resources problems. The proposed research proceeds in two stages. The first stage is to refine the DDDP technique for variable width of its *corridor* and for its conjunctive use with the successive dynamic programming technique in order to achieve maximum efficiency of utilization. The second stage is devoted to investigate new water resources problems such as water quality control and urban water development, and then to apply the new DDDP and MLOM techniques to these models.

(*h*) **Model for Farm Irrigation in Humid Areas,** J. S. Windsor, V. T. Chow. *Trans. ASCE* **137,** 1972, pp. 687-688.

066-08032-810-00

MODELING OF HYDROLOGIC SYSTEMS

(*d*) Theoretical; applied research.
(*e*) A lumped, deterministic, nonlinear mathematical model proposed for the simulation of hydrologic systems is developed from expansion of a general storage function of input and output in Taylor's series about a steady state. The model recommended for practical application is based on the system model in the form of a third-order differential equation, the coefficients of which are considered as functions of the peak discharge of direct runoff. In the analysis of the model, watershed is taken as the hydrologic system. Nine watersheds with more than 70 major and minor storms were used in the analysis and verification of the recommended model. The results indicate a very satisfactory simulation of watershed hydrologic systems by the model.
(*h*) **Hydrologic Modeling – The Seventh John R. Freeman Memorial Lecture,** *Proc. Boston Soc. of Civil Engrg.* **60,** 5, Jan. 1972, pp. 1-27.
Discussion on General Hydrologic System Model, V. T. Chow, V. C. Kulandaiswamy, *J. Hydraul. Div., ASCE* **98,** HY10, Oct. 1972, pp. 1873-1874.
General Hydrologic System Model, V. T. Chow, V. C. Kulandaiswamy, *Trans. ASCE* **137,** 1972, p. 704.
An Introduction to Systems Analysis of Hydrological Problems, V. T. Chow, *Proc. 2nd. Intl. Sem. for Hydrology Professors*, Aug. 2-14, 1970, Utah Water Research Lab., Utah State Univ. 1973, pp. 15-41.

066-08708-810-33

ANALYSIS OF HYDROLOGIC TIME SERIES

(*b*) Office of Water Resources Research.
(*d*) Theoretical, applied research.
(*e*) Various mathematical models for hydrologic time series are investigated in order to develop an adequate model to simulate hydrologic input for the design of hydraulic structures. Emphasis is given to the models of non-Markovian type and to the design of flood-control engineering works and urban storm drainage hydraulic systems. Considerations were made to introduce stochastic concept for the possible modification of EPA storm water management model and other similar models.
(*h*) **Tests of Stationarity of Hydrologic Time Series,** *Proc. Intl. Symp. on Uncertainties in Hydrologic and Water Resources Systems* **1,** Univ. Ariz., Tucson, Ariz., Dec. 1972, pp. 254-272.

066-08709-310-33

FLOOD CONTROL PROJECT EXPANSION MODELING

(*b*) Office of Water Resources Research.
(*d*) Applied research.
(*e*) A mathematical model is developed for a flood control project planning process which considers the combined use of structural and nonstructural alternatives for flood damage reduction. The model is solved by parametric linear programming and discrete differential dynamic programming. It is then applied to an actual project on the Embarras River, Illinois, proposed by the U. S. Corps of Engineers.

066-08710-810-36

METHODS FOR DETERMINING URBAN STORM RUNOFF

(*b*) U. S. Environmental Protection Agency.
(*c*) Professors V. T. Chow and B. C. Yen.
(*e*) To identify the best method or methods for determination of urban storm runoffs on the basis of the design, as well as operational viewpoint, and to recommend the selected methods to engineers for applications. The methods are compared on a common basis by applying them to selected urban drainage basins under identical rainstorms.

066-08711-810-54

HYDRODYNAMIC MODELING OF FLOOD FLOWS

(*b*) National Science Foundation.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Experimental and analytical.
(*e*) To develop an improved advanced hydrodynamic model for analyses of flood flows from watersheds. The complete hydrodynamic equations as well as their various approximate forms will be considered. The result will be useful not only in design and planning for reduction and prevention of flood damages but also as a calibration yardstick for determination of the relative merits of the approximate routing models that are now available.
(*h*) **A Laboratory Watershed Experimentation System,** V. T. Chow, B. C. Yen, Civil Engrg. Studies, *Hydraulic Engrg. Ser. No. 27*, Univ. Ill., Aug. 1974, 200 pages.
The Evaluation of a Hydrodynamic Watershed Model (IHW Model IV), C. H. Hsie, V. T. Chow, B. C. Yen, Civil Engrg. Studies, *Hydraulic Engrg. Series No. 28*, Univ. Ill., Aug. 1974, 143 pages.
Experimental Investigation of Watershed Surface Runoff, Y. Y. Shen, B. C. Yen, V. T. Chow, Civil Engrg. Studies, *Hydraulic Engrg. Series No. 29*, Univ. Ill., Sept. 1974, 197 pages..
Time Concentration for a Watershed, Y. Y. Shen, V. T. Chow, B. C. Yen, *Trans. Am. Geophys. Union* **54,** 11, p. 1087, 1973.
Laboratory Study of Effect of Areal Distribution of Rainfall on Surface Runoff, V. T. Chow, Y. Y. Shen, B. C. Yen, *Trans. Am. Geophys. Union* **54,** 11, p. 1083, 1973.

066-08712-870-33

LABORATORY STUDY OF THERMAL DISCHARGES IN RIVERS AND ESTUARIES

(*b*) Office of Water Resources Research.
(*c*) Professors E. R. Holley and W. H. C. Maxwell.
(*d*) Experimental.
(*e*) Data on arrested thermal wedges have been collected in a 6-ft-wide by 161-ft-long flume for a total flow depth of approximately 1 ft for the case of a smooth bed and for an artificially roughened bed. Data consists of temperature profiles and null velocity point locations. Data are being collected in a 1-ft by 1-ft, 140-ft-long channel to compare interfacial friction effects for an arrested thermal wedge and an arrested cold water intruded wedge.
(*h*) **Discussion of Cooling Water Density Wedges in Stream,** W. H. C. Maxwell, *J. Hydraulics Div., ASCE* **98,** HY8, Aug. 1972, pp. 1459-60.
P-Function Approximations for Jet Momentum Flux, W. H. C. Maxwell, K. C. Chang, *J. Engrg. Mechanics Div., ASCE* **98,** EM4, Aug. 1972, pp. 1011-16.
Axisymmetric Shallow Submerged Turbulent Jets, W. H. C. Maxwell, H. Pazwash, *J. Hydraul. Div., ASCE* **99,** HY4, Apr. 1973, pp. 637-52.

066-08713-060-61

FIELD TESTS ON STRATIFIED FLOWS

(*b*) Illnois Water Resources Center.
(*c*) Professors E. R. Holley and W. H. C. Maxwell.
(*e*) The literature on two-layered stratified flow situations contains very little field data. The objective is therefore to conduct field measurements of velocity and density distributions in two-layered stratified flows, particularly those for which warm water overlies cool water. The data from such tests permit calculation of interfacial shear and mixing characteristics to supplement current laboratory work. Field tests increase the range of depths, velocities, and Reynolds numbers above those which may be investigated in the laboratory.

066-08714-870-33

ADVANCED METHODOLOGIES FOR DESIGN OF STORM SEWER SYSTEMS

(*b*) Office of Water Resources Research.
(*c*) Professors B. C. Yen and H. G. Wenzel.
(*d*) Applied research.
(*e*) To develop an improved methodology for design strategies and procedure for storm sewer systems on the basis of an integrated consideration of hydraulics, risk analysis, cost-damage-benefit relationships, optimization, and systems analysis. Particular consideration is given to the mutual influences of the sewers in the system. The information obtained will be directly useful to the design of urban storm sewer systems, and as a guideline to evaluate simplified appropriate design methods.

066-08715-200-33

HYDRAULIC ROUTING OF FLOODS

(*b*) Office of Water Resources Research.
(*c*) Professor B. C. Yen.
(*d*) Applied research.
(*e*) Mathematical models are being developed to route floods through channels forming a tree-type network. Computational methods in solving the St. Venant equations, including the implicit, explicit, and characteristic schemes are being compared. The relative merits of the various simplified approximation models such as the diffusion, the kinematic-wave, nonlinear, and linear models are also under investigation. Junction effects are being carefully considered.
(*h*) **Comparison of Four Approaches in Routing Flood Wave Through Junction,** A. S. Sevuk, B. C. Yen, *Proc. 15th Congr. Intl. Assoc. Hydraul. Res.* **5**, Istanbul, pp. 169-172, 1973.

066-08716-810-33

METHODOLOGIES FOR FLOW PREDICTION IN URBAN DRAINAGE SYSTEMS

(*b*) Office of Water Resources Research.
(*c*) Professor B. C. Yen.
(*d*) Applied research.
(*e*) Study involves theoretical and experimental investigations directed at determining flow of storm water in urban drainage systems. The urban drainage system is considered as an integrated system of components of urban surface, gutters, inlets, sewer branches, junctions, manholes, and other structures.
(*h*) **Illinois Storm Sewer System Simulation Model: User's Manual,** A. S. Sevuk, B. C. Yen, G. E. Peterson, *Water Resources Center Res. Rept. No. 73*, Univ. Ill., 1973.
Methodologies for Flow Prediction in Urban Drainage Systems, *Water Resources Center, Res. Rept. No. 72*, Univ. Ill., 1973.

066-08717-340-33

CONTROL OF MIXING AT HEATED WATER OUTLETS

(*b*) Office of Water Resources Research.
(*c*) Professor W. H. C. Maxwell.
(*g*) Experimental and analytical.
(*e*) Laboratory experiments will be conducted to determine the effects of wing wall geometry on mixing downstream from submerged slot outfalls near a free surface or near a fixed bed. Current work is being conducted using unheated jets and will be followed by an investigation of density effects when the effluent jet is heated above ambient temperature. The objectives are to develop design parameters for lateral appurtenances in the vicinity of rectangular outfall structures.
(*h*) **The Influence of Surface Tension on Weir Flow,** W. H. C. Maxwell, *J. Hydraul. Res., IAHR* **11**, 3, 1973, pp. 299-303.

UNIVERSITY OF ILLINOIS, Fluid Mechanics and Hydraulics Laboratory, Department of Theoretical and Applied Mechanics, Urbana, Ill. 61801. Professor R. T. Shield, Department Head. Professor J. M. Robertson, Area Coordinator for Fluids.

067-04143-270-60

APPLICATION OF PRINCIPLES OF FLUID MECHANICS TO ANALYSES OF PATHOLOGICAL CHANGES IN THE CEREBRAL CIRCULATION

(*b*) Illinois Department of Mental Health.
(*c*) Prof. M. E. Clark, Talbot Laboratory.
(*d*) Computational, applied research, Ph.D. thesis.
(*e*) This project is concerned with the fluid mechanic aspects of blood circulation in the brain and with factors which control this circulation in normal and diseased states. Cerebral blood flow and pressure distributions obtained from computer models are being compared with animal data obtained under normal and pathological conditions. Current work utilizes numerical methods to describe pulsatile flow in a network of branching and looping flexible vessels which adequately describes the circle of Willis vasculature.
(*h*) **A Circle of Willis Simulation with Unsteady Flows and Flexible Vessels,** R. H. Kufahl, M. E. Clark, *Proc. 27th ACEMB*, p. 206, 1974.

067-05778-030-00

BODY FLOWS AT LOW REYNOLDS NUMBERS

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic analytical and experimental research.
(*e*) Except for flat plate, analytical flow and drag relations are available only in the creeping motion and boundary layer regimes. Experimental data is available only for a few other bodies in the intermediate (Navier-Stokes) range. Objective of study is to help fill this gap.
(*h*) **Higher Order Boundary Layer for Viscous Flow Past Sharp Wedges,** S. N. Evbuoma, J. S. Walker, J. M. Robertson, *AIAA J.* **12**, pp. 1001-1003, 1974.

067-07351-010-00

TURBULENT BOUNDARY LAYER FLOW ON FLAT PLATE

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research; experimental and review of literature.
(*e*) Refurbishing of theory for layer, assessment of transition occurrences in terms of leading edge, stream turbulence level and roughness or trips; a second phase concerns effect of high stream turbulence level on a turbulent layer.
(*f*) Experiments continue on first phase.
(*h*) **Stream Turbulence Effects on Turbulent Boundary Layer,** J. M. Robertson, C. F. Holt, *Proc. ASCE* **98**, HY6, June 1972.

067-07352-120-00

FORCES ON BODIES IN NON-NEWTONIAN FLUIDS

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research; also Ph.D. thesis.
(*e*) Nature of body-force relations (particularly drag) for bodies in relative motion with fluids such as Bingham plastics. Experiments have been carried out with clay-water mixtures (and on their viscometry) and are planned for other fluids. Analytical work on extending theoretical formulations.

067-07353-630-70

NOISE PRODUCTION IN FLUID-POWER SYSTEMS

(*b*) Sundstrand Aviation.
(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research, analytical in nature with experiments planned.
(*e*) The manner of noise generation by pressure transients in the cylinders of positive-displacement pumps is being stu-

died via analysis and analog experiments (water table) of wave motions.

(*h*) **Analysis of Transient Wave Motion in Liquid Filled Cylinders,** C. F. Holt, *TAM Rept. 363*, 1972.

067-07355-000-88

NUMERICAL ANALYSIS OF LAMINAR OSCILLATORY NAVIER-STOKES FLOWS PAST TWO-DIMENSIONAL AND AXISYMMETRIC HUMPS

(*b*) National Science Foundation.
(*c*) Professor M. E. Clark, Talbot Laboratory.
(*d*) Theoretical and experimental research.
(*e*) Fluid dynamic occurrences in simple conduits for flows through various types of geometric barriers are being theoretically and experimentally correlated for comparison with hemodynamic occurrences in similar physiological situations. This research attempts to develop the analysis by finite difference solution of the appropriate Navier-Stokes equations for pressure, shear and vorticity.
(*g*) Some preliminary results for square humps in the plane case have been achieved at low and moderate values of the oscillatory flow parameter $D(f/\nu)^{\cdot}$ (D is the plate spacing, f frequency of oscillation, and ν the kinematic viscosity of fluid) and over the lower end of the physiological range of the Karman number $MD^3/\rho\nu^2$ (ρ is fluid density and M is amplitude of driving pressure gradient).
(*h*) **Numerical Calculations of Plane Oscillatory Non-Uniform Flow - II. Parametric Study of Pressure Gradient and Frequency Effects with Square Wall Obstacles,** L. C. Cheng, J. M. Robertson, M. E. Clark, *J. Biomechanics* **6,** pp. 521-538, 1973.
Plane Oscillatory Flow Past Rectangular Obstacles, L. C. Cheng, M. E. Clark, J. M. Robertson, *J. Eng. Mechs. Div., Proc. ASCE* **100,** EM4, 1974, pp. 707-718.
Calculation of Plane Pulsatile Flow Past Wall Obstacles, L. C. Cheng., J. M. Robertson, M. E. Clark, *Computers and Fluids* **2,** pp. 363-380, 1974.
True Pulsatile Flow Past Axisymmetric Conduit Non-Uniformities, M. E. Clark, J. M. Robertson, L. C. Cheng, *Proc. 27th ACEMB*, p. 205, 1974.

067-08034-110-54

LIQUID-METAL PIPE FLOWS WITH STRONG MAGNETIC FIELDS

(*b*) National Science Foundation.
(*c*) Professor J. S. Walker, Talbot Laboratory.
(*d*) Theoretical.
(*e*) This project involves a large number of separate but closely related studies of three-dimensional liquid-metal magnetohydrodynamic (MHD) flows in the presence of strong applied magnetic fields. An extensive study of flows through rectangular and circular expansions and contractions has recently been completed. Currently active studies of liquid-metal MHD flows include periodic fluid transients and waterhammer waves, open-channel flows, laminarization of turbulence by magnetic fields, effects of wall roughness and effects of small magnetic-field gradients. Applications of the results will include calculation of power required to pump liquid-metal coolants through the strong magnetic fields needed to confine the plasma in fusion reactors, and design calculations for MHD pumps and devices for metal foundries and for liquid-metal fast breeder reactors.
(*h*) **Duct Flows in Strong Magnetic Fields,** J. S. Walker, G. S. S. Ludford, *Proc. 10th. Anniv. Mtg. Soc. Engrg. Science*, 1973.
Periodic Fluid Transients in Rectangular Ducts With Transverse Magnetic Fields, J. S. Walker, *Z. Angew. Math. Phys.* **25,** 1974.

067-08035-130-00

FLUID CONVEYANCE OF PARTICLES IN VERTICAL PIPES

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research; student project.
(*h*) **Vertical Pipe Transport of Particles in Dilute Concentration,** A. M. Melone, J. M. Robertson, *ASME 1973 Cavitation and Polyphase Flow Forum*, pp. 17-18.

067-09036-210-52

WATERHAMMER WAVES IN CURVED PIPES

(*b*) Argonne National Laboratory.
(*c*) Professor J. W. Phillips, Talbot Laboratory.
(*d*) Theoretical and experimental.
(*e*) Study treats the effects of tube curvature on waterhammer waves propagating along helical tubes or through tube bends. The results will be applied to disaster predictions for liquid-metal fast breeder reactors.

067-09037-110-00

FERROHYDRODYNAMIC BOUNDARY LAYERS

(*c*) Professor J. D. Buckmaster, Talbot Laboratory.
(*d*) Theoretical.
(*e*) Study treats boundary layers on bodies moving through ferroliquids in the presence of magnetic fields. Ferroliquids promise to play a major role in fluidic control devices and in high-speed printers using jets of ferroliquid ink controlled by magnetic fields. A good understanding of boundary layers in ferroliquids will be needed to make design predictions for these devices.
(*h*) **Ferrohydrodynamic Boundary Layers,** J. D. Buckmaster, *Proc. 10th Anniv. Mtg. Soc. Engrg. Science*, 1974.

067-09038-000-54

STEADY FLOW THROUGH ROTATING VARIABLE-AREA DUCTS

(*b*) National Science Foundation.
(*c*) Professor J. S. Walker, Talbot Laboratory.
(*d*) Theoretical.
(*e*) Study treats liquid flows in expansions and contractions rotating about axes perpendicular to their centerlines. The results will relate directly to flows inside the impellers of hydraulic turbines and centrifugal pumps and indirectly to the effects of bottom topology on ocean currents.
(*h*) **Steady Flow in Rapidly Rotating Circular Expansions,** J. S. Walker, *J. Fluid Mech.* **66,** 1974, p. 657.

067-09039-030-54

LARGE AMPLITUDE MOTION OF SELF-PROPELLING FILAMENTS

(*b*) National Science Foundation, Ford Foundation.
(*c*) Professor T. J. Lardner, Talbot Laboratory.
(*e*) An analysis of the hydrodynamics of filaments moving with finite amplitude sinusoidal motions has been completed. Expressions for various important physical quantities, such as propulsive velocity, normal and tangential drag coefficients, and power dissipation were obtained. The results can be used for a simplified analysis for filaments of non-zero thickness undergoing large amplitude motions.
(*h*) **Observations on the Hydrodynamics of Swimming Spermatozoa,** T. J. Lardner, C. Fray, W. Shaih, *Bull. Math. Biology* **36,** pp. 555-565, 1974.

067-09040-030-80

APPLICABILITY OF HYDRODYNAMIC ANALYSES OF SPERMATOZOAN MOTION

(*b*) Ford Foundation, National Science Foundation.
(*c*) Professor T. J. Lardner, Talbot Laboratory.
(*e*) An investigation of the applicability of a simplified hydrodynamic analysis to the quantitative description of the motion of both sea urchin and mammalian sperm has been completed. A comparison of experimentally measured and theoretically predicted motions was made to check the validity of the analysis. The results for the sea urchin sperm showed good agreement, while the results for mammalian sperm showed poor agreement.
(*h*) **A Long Wave Length Approximation to Spermatozoan Swimming in a Channel,** T. J. Lardner, W. Shack, *Bull. Math. Biology* **36,** pp. 435-442, 1974.

The Swimming of Spermatozoa in An Active Channel, T. J. Lardner, R. Smelser, W. Shack, *Bull. Math. Biology* **7**, pp. 349-355, 1974.

067-09041-020-54

STATISTICAL THEORY OF TURBULENCE

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Talbot Laboratory.
(*d*) Theoretical.
(*e*) A model equation for the probability density of temperature and velocity has been used in the investigation of various turbulent flows with buoyancy, including homogeneous stratified shear flows with arbitrary Richardson number, inhomogeneous Rayleigh convection, and inhomogeneous convection in the asymptotic limit of large negative Richardson members. In the last case it is found that the empirical power laws for local free convection are similarity solutions of the p.d.f. equation.

067-09042-020-54

UNSTEADY TURBULENT FREE CONVECTION

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Talbot Laboratory.
(*d*) Experimental.
(*e*) Unsteady turbulent free convection over large horizontal surfaces is an important phenomenon in the planetary boundary layer that is being studied experimentally on the laboratory scale. The experiments involve the measurement of fluctuating velocities and temperatures using a two component laser Doppler velocimeter and very small temperature sensors which are scanned through the fluid. The experimental objectives include the measurement of the terms appearing in the balance equations for mean turbulent kinetic energy and heat flux and the application of conditional averaging techniques in order to better define quasi deterministic structures within the flow.

067-09043-700-54

EFFECTS OF SNR ON THE FREQUENCY DEMODULATIONS OF LDV SIGNALS

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Talbot Laboratory, Professor J. H. Whitelau, Imperial College, Mr. J. C. Humphrey, Imperial College.
(*d*) Experimental and theoretical.
(*e*) The laser-Doppler velocimeter is becoming an increasingly more important tool in hydraulics research. In general, the measured frequency of a laser-Doppler velocimeter signal that contains noise is not equal to the frequency of the pure Doppler signal. The relationship between measured and true frequency is being investigated theoretically for the limiting cases of very small and very large scattering particle concentrations. The analyses consider the effects of several parameters, including long-term signal-to-noise ratio (SNF) frequency detector threshold levels, the Doppler signal visibility with respect to the threshold, and the noise bandwidth. It is found that errors in excess of one-hundred percent can be made when the SNR is low.

067-09044-700-54

TWO-DIMENSIONAL BI-POLAR LASER DOPPLER VELOCIMETER

(*c*) Professor Ronald J. Adrian.
(*d*) Experimental.
(*e*) A laser-Doppler velocimeter is being developed for the measurement of local, instantaneous fluid velocities in the range of 0.01 cm sec^{-1}. The instrument utilizes an equilateral three-beam configuration in which two of the beams are frequency shifted by an acousto-optic modulator. This arrangement permits measurement of two orthogonal velocity components, and their signs in regions close to a flow boundary. In particular, measurements of the normal component in wall turbulence are possible.
(*h*) **A Bi-Polar, Two-Dimensional LDV for Near Wall Measurements,** *Proc. 2nd. Intl. Workshop on Laser Velocimeter*, Purdue University.

067-09045-700-54

ELECTROMAGNETIC SCATTERING THEORY OF LASER-DOPPLER VELOCIMETERS

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Mr. W. Earley, Talbot Laboratory.
(*d*) Theoretical.
(*e*) In the measurement of both liquid and gas velocities, the performance of an LDV can be substantially up-graded by suitable choices of scattering particles and light receiving apertures. In this study the strength and quality of an LDV signal obtained from a single scattering particle depend strongly on the particle's scattering properties and on the size and shape of the light collecting aperture. Using the Mie scattering theory, an analysis of these effects is being performed which predicts the magnitude, phase and polarizing of the Doppler and pedestal components of an LDV signal in terms of the illuminating beam geometry, the particle properties, and the receiving aperture. Systems having either two or three illuminating beams with arbitrary polarization are considered.

INDIANA UNIVERSITY, Department of Geology, 1005 East Tenth Street, Bloomington, Ind. 47401. Dr. Haydn H. Murray, Department Chairman.

068-08687-820-61

FLUOROCARBONS IN HYDROLOGY

(*b*) WRRC, Indiana University.
(*d*) Determination of the amount of natural fluorocarbons in groundwaler and the use of artificially induced fluorocarbons as tracers. Also, to develop a method of dating groundwater using freons.
(*h*) **Fluorocarbon Tracers in Hydrology,** G. M. Thompson, J. M. Hayes, S. N. Davis, *Geophysical Research Letters* **1**, 4, pp. 177-180., 1974.

INGERSOLL-RAND RESEARCH, INC., Fluid Mechanics and Thermal Sciences Section, P.O. Box 301, Princeton, N. J. 08540. Dr. W. A. McGahan, Director of Research.

069-09027-610-00

HYDRAULICALLY ACTUATED ROCK DRILL

(*c*) Dr. E. Krasnoff and George Schivley.
(*d*) Experimental and theoretical; applied research and development.
(*e*) Study of a new class of high efficiency, hydraulically actuated rock drill. The design concept which involves the reciprocating piston as the only moving part, was modeled analytically to account for system non-linearities as well as important fluid inertia and line pressure wave effects. Concurrent tests were performed with the aid of a specially designed impact dynamometer and instrumentation included high frequency response optical and pressure transducers.
(*f*) Completed.
(*g*) The valveless hydraulic actuator concept was developed and optimized in view of excellent correlation between theory and experiment. Various modes of impacting and idling motion were accurately predicted and the computer program is currently in use as the design tool for commercial rock drill programs.
(*h*) Internal reports and see **Industry-Wide Trend Toward All-Hydraulically Powered Rock Drill,** R. L. Bullock, *Mining Congress J.*, Oct. 1974, pp. 54-65.

069-09028-870-00

COUNTERCURRENT FLOTATION SEPARATOR

(*c*) Dr. E. Krasnoff.
(*d*) Experimental; research and development.
(*e*) Applied research on the dissolved air flotation of biological mixed liquors (activated sludge process) was performed to determine the important process design parameters. Both batch and continuous flow process studies were made on a laboratory scale. The hydrodynamics of bubble generating nozzles and the three-phase flow field investigation led to a new design concept for dissolved air flotation units. Performance was determined over a range of influent flow rates and correlated with three process parameters, namely, air-solids ratio, a bubble number density parameter, and the bubble nozzle pressure ratio.
(*f*) Completed.
(*g*) Experimental research has shown that proper hydrodynamic design leads to efficient dissolved air flotation clarification of biological mixed liquors. Effluent suspended solids of less than 10 parts per million were obtained at influent flow rates up to about 1800 gallons per day in a 4.5 gallon capacity laboratory unit. Test results demonstrate the conditions of operating process parameters which lead to poor control and, ultimately, to upset.
(*h*) **Internal reports;** submitted for presentation *Ann. WPCF Conf.*, Oct. 5-10, 1975, Miami Beach, Fla.

069-09029-630-00

PERFORMANCE AND STABILITY OF PUMP BALANCE DRUM ASSEMBLIES

(*c*) Dr. E. Krasnoff.
(*d*) Theoretical; design.
(*e*) A digital computer model was used to study the hydrodynamics of large, high pressure pump balance drum mechanisms. The model properly accounts for structural deflections, under hydrodynamic pressure loads as well as built-in taper in the radial outflow passage. Turbulent flow relations are used throughout and the input variables include boundary pressures and shaft speed.
(*f*) Completed.
(*g*) The computer model was used to study the balance drum of a specific pump and delineated the design and operating conditions which lead to balance drum instability. Design studies which followed produced designs which were both stable and produced low leakage rates.
(*h*) Internal reports.

069-09030-630-70

COVER GAS SEAL DEVELOPMENT PROGRAM

(*b*) Breeder Reactor Dept., General Electric Co.
(*c*) Dr. G. W. Pfannebecker.
(*d*) Experimental and analytical; applied research and development.
(*e*) Development of a non-rubbing hydrostatic cover gas seal for the LMFBR Demonstration Plant main circulating pumps.
(*g*) Design of seal assembly and test rig to simulate pump operation have been completed. Manufacture of hardware in progress.
(*h*) Internal progress reports.

069-09031-870-00

COOLING TOWER RECIRCULATION MODEL STUDY

(*c*) Dr. T. N. Chen, D. Thompson.
(*d*) Experimental, applied research and development.
(*e*) Study of exhaust plume recirculation for spray pond. Investigate amount of recirculation as function of spray pond geometry (linear, annular), wind magnitude and direction, exhaust velocity, and thermal buoyancy (plume temperature).
(*f*) Completed.
(*g*) Atmospheric wind profile was modeled and recirculation was characterized for each geometry in terms of wind/discharge velocity ratio. Recirculation was found to be maximum for linear arrangement of spray pond with axis parallel to wind, and minimum for annular geometry. Presence of stack, equal in height to that of original pond, placed over outer perimeter of pond reduced recirculation approximately 50 percent.

069-09032-870-00

SPRAY POND MODULE-FIELD TEST

(*c*) Dr. T. N. Chen, D. Thompson.
(*d*) Experimental and theoretical applied research and development.
(*e*) Field study of a new spray pond design utilizing multi-level oriented sprays directed to a central area to induce sufficient air flow for satisfactory cooling under zero wind conditions. Design parameters include nozzle angle, nozzle pressure, water loading, nozzle spacial arrangement, fill depth, and size of central area.
(*g*) Cooling and air induction capabilities have been optimized in terms of design variables. In addition an analytical/empirical design index has been developed as a function of design geometries which enables performance predictions for any ambient/water conditions.

INTERNATIONAL BUSINESS MACHINES CORPORATION, Research Laboratory, Hydrodynamics Group, Monterey and Cottle Roads, San Jose, Calif. 95193. D. E. Rosenheim, Director.

071-07366-740-00

DESIGN, DEVELOPMENT AND APPLICATION OF NUMERICAL METHODS IN THE SOLUTION OF NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS BY FINITE DIFFERENCE METHODS

(*c*) J. E. Fromm, K01/282.
(*d*) Theoretical; basic research.
(*e*) Finite difference algorithms are designed to replace a set of coupled nonlinear partial differential equations, thereby permitting step by step integration through systems of algebraic equations. Initial-boundary value problems are addressed through conditions established on a finite net of points. The objective is to establish accurate and stable difference approximations, program them for efficient computation, and to test their validity in applications where no other means of solution exist.
(*f*) Temporarily discontinued.
(*g*) Fourth order nonlinear algorithms have been developed which extend the range of parameters that may be treated in applications; numerical solutions of buoyant air circulation in rooms.
(*h*) **A Numerical Method for Computing a Nonlinear Time Dependent Buoyant Circulation of Air in Rooms,** J. E. Fromm, *IBM J. Res. and Develop.* **15**, pp. 186-196, May 1971.
A Numerical Study of Buoyancy Driven Flows in Room Enclosures, J. E. Fromm, *Proc. 2nd Intl. Conf. Numerical Methods in Fluid Dynamics, Lecture Notes in Physics* **8**, Springer-Verlag, pp. 120-126, 1970.

INTERNATIONAL BUSINESS MACHINES CORPORATION, Thomas J. Watson Research Center, Post Office Box 218, Yorktown Heights, N. Y. 10598. Dr. R. E. Gomory, Director.

072-07367-810-20

HYDROLOGY PROGRAM

(*b*) Office of Naval Research.
(*c*) Dr. J. S. Smart.
(*d*) Basic and applied theoretical research.
(*e*) Stochastic hydrology and geomorphology.
(*h*) **Subsurface Hydrology at Waste Disposal Sites,** R. A. Freeze, *IBM J. Res. Develop.* **16**, pp. 117-129, 1972.

Best One Step Ahead Prediction in Hydrology, J. R. Wallis, *Water Resour. Res.* **8,** p. 529, 1972.
Sensitivity of Reservoir Design to the Generating Mechanism of Inflows, J. R. Wallis, N. C. Matalas, *Water Resour. Res.* **8,** pp. 634-641, 1972.
Channel Networks, J. S. Smart, *Advances in Hydroscience* **VIII,** Academic Press, N. Y., 1972.
Quantitative Properties of Delta Channel Networks, J. S. Smart, V. L. Moruzzi, *Zeits. f. Geomorph.* **16,** pp. 268-282, 1972.
Quantitative Characterization of Channel Network Structure, J. S. Smart, *Water Resour. Res.* **8,** pp. 729-736, 1972.
Eureka! It Fits a Pearson Type 3 Distribution, N. C. Matalas, J. R. Wallis, *Water Resour. Res* **9,** pp. 281-289, 1973.
Mathematical Simulation of the Subsidence of Venice, G. Gambolati, R. A. Freeze, *Water Resour. Res.* 9, pp. 721-733, 1973.
Some New Methods of Topologic Classification of Channel Networks, C. Werner, J. S. Smart, *Geog. Analysis* **5,** pp. 271-295, 1973.
Optimal Design and Operation of Water Distribution Systems, U. Shamir, *Water Resour. Res.* **10,** pp. 27-36, 1974.
The Random Model in Fluvial Geomorphology, J. S. Smart, *Proc. Symp. on Fluvial Geomorphology*, pp. 25-49, Suny, Binghamton, 1973.
Just a Moment!, J. R. Wallis, N. C. Matalas, J. R. Slack, *Water Resour. Res.* **10,** pp. 211-219, 1974.
Mathematical Simulation of Subsurface Flow Contributions to Snowmelt Runoff, Reynolds Creek Watershed, Idaho, G. R. Stephenson, R. A. Freeze, *Water Resour. Res.* **10,** pp. 284-294, 1974.
Mathematical Simulation of the Subsidence of Venice, 2. Results, G. Gambolati, P. Gatto, R. A. Freeze, *Water Resour. Res.* **10,** pp. 563-577, 1974.

IOWA INSTITUTE OF HYDRAULIC RESEARCH, University of Iowa, Iowa City, Iowa 52242. Dr. John F. Kennedy, Director.

073-00066-810-05

HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED

(*b*) Agricultural Research Service and U.S. Geological Survey.
(*c*) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, Univ. of Iowa.
(*d*) Field investigation, applied research, and M.S. theses.
(*e*) Study continuously in progress since 1924 on the three square-mile north branch of Ralston Creek. This involves discharge measurement by the U.S.G.S. and rainfall measurement at five automatic recording stations. It is collected by the Agricultural Research Service and published by the Weather Bureau. An area of similar size on the south branch of Ralston Creek came under observation in 1967. A record of the urbanization of the area through aerial photos and numerous pictures taken at the same point year after year is being accumulated. Records on rainfall, runoff, groundwater levels, sediment transportation, and land use are combined in an annual report.
(*g*) Yearly records available for examination at Iowa Inst. of Hydraulic Research.
(*h*) Reports prepared annually since 1924 available in files at the Iowa Inst. of Hydraulic Research. Summary of 33-year record published as *Bull. 16 of the Iowa Highway Research Board* in 1961; available on loan from Iowa Highway Commission, Ames, Iowa.

073-00067-810-30

COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA

(*b*) U. S. Geological Survey, Agric. Research Service, Natl. Weather Service, IIHR, Graduate College.
(*c*) District Chief, Water Resources Div., U. S. Geol. Surv., Iowa City, Iowa.
(*d*) Field investigation; collection of basic streamflow data.
(*e*) Streamflow and sediment measuring stations maintained throughout the State of Iowa cooperatively on a continuous basis. Records collected by standard methods of U.S.G.S.
(*g*) Records of streamflow and sediment discharge computed yearly.
(*h*) Records contained in open-file reports published annually, and in Water-Supply Papers published at five year intervals; available from U. S. Geological Survey.

073-02091-520-20

RESEARCH ON SHIP THEORY

(*b*) Office of Naval Research and Naval Ship Research and Development Center.
(*c*) Dr. L. Landweber.
(*d*) Experimental and theoretical; basic research.
(*e*) Determine the laws governing the forces, moments, and motions of ships. Work is under way on development of procedure for computing potential flow about ship forms; higher-order gravity wave theory for ship forms and an immersed prolate spheroid; effect of tank size on ship-model resistance; resolution of viscous and wave drag by means of wake and surface-profile measurements; conformal mapping of ship sections; thick boundary layers about bodies of revolution; effect of a dilute solution of guar-gum on resistance.
(*h*) **Contributions on Some Current Problems on Ship Resistance,** L. Landweber, Invited Paper, *Netherlands Ship Model Basin 40th Anniv.*, Delft, Holland, Sept. 1972.
Elimination of Corners in the Mapping of a Closed Curve, L. Landweber, *J. Engrg. Mathematics*, Oct. 1972.
Irrotational Axisymmetric Flow about a Body of Revolution in a Tube, L. Landweber, K. Gopalakrishnan, *Schiffstechnik* **20,** Nov. 1973.
Frictional Resistance of Flat Plates in Dilute Polymer Solutions, L. Landweber, M. Poreh, *J. Ship Res.*, Dec. 1973.
Investigations on Components of Ship Resistance, L. Landweber, *IIHR Report No. 168*, May 1974.
Prediction of the Viscous Resistance of Ships Using Equivalent Bodies of Revolution, L. Landweber, A. Nakayama, V. C. Patel, *Proc. 17th ATTC*, June 1974, to be published.
Velocity Correction due to Tank Blockage, L. Landweber, A. Nakayama, *Proc. 17th ATTC*, June 1974, to be published.
Further Developments of a Procedure for Determination of Wave Resistance from Longitudinal-Cut Surface-Profile Measurements, L. Landweber, E. E. Tsai, accepted for publication in *J. Ship Research.*
Axisymmetric Potential Flow in a Circular Tube, L. Landweber, *J. Hydronautics* **8,** 4, Oct. 1974.
Experimental Study of the Wavemaking of Horizontally-Oriented Vorticity in a Wake, L. Landweber, A. Swain, *IIHR Rept. No. 153*, Jan. 1974.
A Perturbation Analysis of the Wavemaking of a Ship with an Interpretation of Guilloton's Method, F. Noblesse, *Ph.D. Thesis*,Univ. of Iowa, Dec. 1974.
Viscid-Inviscid Interaction Due to the Thick Boundary Layer Near the Tail of a Body of Revolution, A. Nakayama, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1974.

073-06362-020-20

TURBULENT MIXING OF DENSITY STRATIFIED LIQUIDS

(*b*) Office of Naval Research, Dept. of the Navy.
(*c*) Dr. C. Farell.
(*d*) Experimental and analytical; basic research and graduate thesis.
(*e*) Measurement of the turbulence characteristics of the flow in the wake of a grid towed through a linearly density-stratified liquid, with the aim of determining the effect of

the density stratification on the turbulence fluctuations and turbulent mixing, the degree of stratification recovery at various distances behind the grid, and the correlation between turbulent velocity and salinity fluctuations.

(*f*) Completed.

(*g*) Experiments have been completed with a 1-1/2 in. square-mesh biplane grid made of 1/2-in. square bars and towed at 0.5 fps through a saline solution with a linear density stratification of one percent per foot. The root-mean-square of the longitudinal velocity fluctuations has been found to decrease first, then increase, and, finally level off with distance downstream from the grid. The same trend, but with much smaller variations, is exhibited by the root-mean-square value of the vertical velocity fluctuations. The transverse horizontal component of the velocity exhibits on the other hand the same behavior as in a homogeneous fluid. The cross-correlation between the vertical velocity component and the density fluctuations is a nearly even function at small distances from the grid (as indicated by the values of the quadrature spectra being much smaller than the values of the corresponding cospectra) and becomes a nearly odd function at large distances from the grid (where the quadrature spectra are dominant).

(*h*) **Turbulent Mixing of Density Stratified Fluids,** M. C. Tao, *Ph.D. Thesis*, Univ. of Iowa, Jan. 1971.
Grid Turbulence in Density-Stratified Fluids, C. Farell, M. C. Tao, presented *19th. Ann. Hyd. Div. Conf., ASCE*, Univ. of Iowa, Aug. 1971.

073-07368-410-11

SEDIMENT ENTRAINMENT AND SUSPENSION BY SHOALING WAVES

(*b*) Coastal Engrg. Res. Center, U.S. Army Corps of Engineers.

(*c*) J. R. Glover and J. F. Kennedy.

(*d*) Experimental and theoretical; basic research; Ph.D. thesis.

(*e*) Experiments were conducted in oscillatory flow, "U-Tube" water tunnel, with the goal of determining the spatial and temporal distributions of suspended sediment concentration and velocity in oscillatory flows over rippled beds. Both a rippled, sediment bed and a rigid bed with a limited supply of sediment on it were utilized. Suspended sediment concentrations were measured by means of the Iowa electro-optical system, while crossed, coated hot wires were used to measure velocities. The outputs of the concentration and velocity transducers were sampled by means of an on-line computer using a signal-averaging procedure. The distributions of the mean, periodic, and random components of the concentration and velocity distributions were determined, as were the cross-correlations significant to the sediment continuity relation.

(*g*) The experiments indicate that the mean sediment concentration diminishes very rapidly with elevation above the bed. Within each wave period there are four concentration peaks; each of these traces its origin to the sediment entrained from a ripple crest and swept past the probe. The peak magnitude of the periodic component of the concentration is comparable in magnitude and nearly linearly proportional to that of the mean concentration at a point. Considerable difficulty was encountered in measuring the velocities, due to the interaction between the sediment particles and the hot wire probes. The experimental data on the cross correlations interpreted in the light of the one-dimensional sediment continuity relation (the Schmidt equation) indicated that the longitudinal transport of sediment is very important, i.e., a simple balance does not exist between the settling velocity and the upward sediment diffusion velocity. The ripples were found to play a very dominant role in the sediment entrainment and suspension process. The large, captive eddy generated in the lee of each ripple during each half-period and the intense shear stress on the stoss side of each ripple throw the sediment into suspension and are largely responsible for maintenance of the suspended sediment field. The presence of sediment significantly alters the flow characteristics, amplifying both the mean and fluctuating components of the turbulent components of the velocity.

(*h*) **Investigation of the Operating Characteristics of the Iowa Sediment Concentration Measuring System,** F. A. Locher, J. R. Glover, T. Nakato, *Iowa Inst. of Hydr. Res. Tech. Rept. No. 170*, Nov. 1974.
A Computer-Based Electro-Optical System for Measuring Wave-Induced Sand Concentrations, J. R. Glover, F. A. Locher, P. K. Bhattacharya, *J. Basic Engrg., ASME*, June 1972.
Wave-Induced Sediment Entrainment from Rippled Beds, T. Nakato, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1974.

073-07370-300-54

DYNAMICS OF ICE COVERED STREAMS

(*b*) National Science Foundation.

(*c*) John F. Kennedy.

(*d*) Experimental and theoretical; basic research; Doctoral theses.

(*e*) An analytical and experimental study of the strength of columnar ice; the stability of turbulent flows of water past ice boundaries; failure criteria for ice; and the winter thermal regime of rivers.

(*g*) A series of experiments was conducted in a specially designed tank equipped with a motor driven carriage and dynamometer to determine the forces exerted on cylindrical piles acted upon by moving ice sheets. An empirical formula was developed for the calculation of the maximum penetration strength of circular piles. Good agreement was found between the laboratory based relation and field data. The formula was modified for application to different structural shapes and various degrees of contact between the ice and the structure, and for application to the case of pile indentation. The analytical and experimental study of the spectral evolution of ice ripples revealed that there is no significant shift in the spectral content of ripple profiles as they develop from an initially plane interface. It was found that there is relatively little interaction among the various spectral components present in the profile. Therefore, the results of the earlier investigation of monochromatic ripples can be applied by linear superposition to more complex profiles. A new "dual failure" criterion was developed to predict the failure of ice and other brittle materials. The new analytical model yields better predictions of the failure under tension or compression loading than those heretofore available. A numerical model has been developed to predict the winter thermal regime of rivers, and to calculate the streamwise temperature distribution downstream from imposed thermal loads. The analytical model includes the full one-dimensional convection-diffusion equation and a surface heat-transfer predictor that includes all of the principal modes of heat transfer.

(*h*) **An Investigation of Ice Forces on Vertical Structures,** K. I. Hirayama, *Ph.D. Thesis*, Univ. of Iowa, May 1974.
An Investigation of Ice Forces on Vertical Structures, K. T. Hirayama, J. Schwarz, H. C. Wu, *Iowa Inst. of Hydr. Res. Tech. Rept. No. 158*, June 1974.
Model Techniques for the Investigation of Ice Forces on Structures, K. I. Hirayama, J. Schwarz, H. C. Wu, *2nd Intl. Conf. on Port and Ocean Engrg. Under Arctic Conditions*, 1974.
Effect of Ice Thickness on Ice Forces, J. Schwarz, K. I. Hirayama, H. C. Wu, *Offshore Technology Conf., Paper No. OTC 2048*, May 6-8, 1974.
Modelltechnik für Eisdruckversuche, J. Schwarz, *Schiff und Hafen, Sonderausgabe EUROPORT/Interocean*, Nov. 1973.
Failure Criterion for Plain Concrete Under Short-Time Load, H. C. Wu, *Iowa Inst. of Hydr. Res. Tech. Rept. No. 149*, Nov. 1973.
Dual Failure Criterion for Plain Concrete, H. C. Wu, *J. Engr. Mech. Div., ASCE* **100**, EM6, Dec. 1974.
Compression of Columnar-Grained Ice and Some Further Aspects of Brittle Fracture, K. J. Chang, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1974.
Spectral Evolution of Ice Ripples, K. S. Hsu, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1973.

Ripples on Underside of River Ice Covers, G. D. Ashton, J. F. Kennedy, *J. Hyd. Div., Proc. ASCE* **98,** HY9, Sept. 1972.

073-07376-270-40

FLUID MECHANICS OF THE SMALL INTESTINE

(*b*) National Institutes of Health.
(*c*) Dr. E. O. Macagno.
(*d*) Experimental and analytical; basic research, graduate thesis.
(*e*) Kinematical study of the wall motions of the small intestine. Emphasis directed at description of contractions of the circular and longitudinal muscle layers. Analytical and model study of flows induced by wall motions. Model study of performance of pressure sensors used for *in vivo* small bowel manometric studies.
(*g*) A statistical-deterministic model of duodenal pumping has been formulated and long-term, expected flow rates predicted. An initial description of longitudinal contractions and the resulting flow has been developed.
(*h*) **Fluid Mechanics of the Human Duodenum,** R. Singerman, *Ph.D. Thesis,* Univ. of Iowa, May 1974.
A Statistical Study of the Spike Bursts on the Slow Wave in the Duodenum, A. G. Sancholuz, *M.S. Thesis,* Univ. of Iowa, July 1974.
Longitudinal Motility in the Duodenum, E. O. Macagno, J. Melville, J. Christensen, *Proc. 95th Winter Ann. Mtg., ASME, Bioengrg. Div.,* Nov. 17-22, 1974.

073-07378-060-33

NATURAL MIXING AND TRANSFER PROCESSES FOR THERMAL LOADS IN STREAMS

(*b*) Office of Water Resources Research, Dept. of the Interior.
(*c*) Dr. W. W. Sayre.
(*d*) Experimental and analytical; laboratory investigation; applied research, contributing toward Ph.D. theses.
(*e*) See 1970 Water Resources Research Catalog.
(*f*) Completed.
(*h*) **Vertical Mixing of Heated Effluents in Open-Channel Flow,** E. J. Schiller, W. W. Sayre, *Completion Rept. Project No. A-040-IA,* Iowa State Water Resour. Res. Inst., Ames, Iowa, Aug. 1973.

073-08036-060-33

MIXING AND TRANSFER OF HEAT IN OPEN CHANNEL FLOW

(*b*) Office of Water Resources Research, Dept. of the Interior.
(*c*) Dr. W. W. Sayre.
(*d*) Experimental (laboratory) and theoretical; applied research, contributing toward M.S. and Ph.D. theses.
(*e*) Investigation of the processes by which effluent heated water mixes with flowing streamwater, and the excess heat is transferred to the surrounding environment, and how these processes combine to produce a particular temperature distribution pattern in the stream. Influence of density gradient on vertical distribution of longitudinal velocity.
(*g*) Depth-averaged vertical mixing coefficients, ϵ_v/u_1d, found to vary from about 0.005 for initial densimetric Froude number, IF_{Do}, of 1 to an asymptotic value of 0.063 for $IF_{Do} \geq 10$. In addition to suppressing vertical turbulent mixing, vertical density gradient suppresses corner-generated secondary circulation. Buoyancy-induced secondary circulation significantly increases initial rate of transverse spreading. For u_1 $(\Delta\rho g d/\rho)^{1/2}$ buoyancy effects are especially strong, and bimodal transverse temperature distributions occur. Buoyancy effects can either increase or decrease the rate of longitudinal spreading by an amount which is not large. In a density-stratified flow, the velocity is increased slightly near the water surface and retarded slightly in the lower part of the flow. The effect is insignificant for $IF_{Do} > 1.5$.
(*h*) **Vertical Mixing of Heated Effluents in Open Channel Flow,** E. J. Schiller, *Ph.D. Thesis,* Univ. of Iowa, July 1973.
Vertical Mixing of Heated Effluents in Open-Channel Flow, E. J. Schiller, W. W. Sayre, *Iowa Inst. of Hydr. Res. Rept. No. 148,* July 1973.
Transverse Mixing of Heated Effluents in Open-Channel Flow, T. P. Yeh, *Ph.D. Thesis,* Univ. of Iowa, May 1974.

073-08037-060-33

OPERATIONAL CHARACTERISTICS OF DIFFUSER PIPES FOR DISPERSING HEATED EFFLUENTS IN RIVERS

(*b*) Commonwealth Edison Co., Chicago; Office of Water Resources Research, Dept. of the Interior.
(*c*) Dr. W. W. Sayre.
(*d*) Experimental, laboratory investigation; applied research for M.S. theses.
(*e*) Investigation of the operating characteristics of buried multiple-port diffuser pipes for dispersing heated effluents in rivers with a view toward evaluating the degree of mixing in the channel downstream as a function of the spacing of discharge ports, and eliminating and/or suppressing thermal wedges which occur upstream from diffuser pipes at low densimetric Froude numbers.
(*f*) Completed.
(*g*) In the mixing investigation the spacing between ports was varied from 0.6 to 2.5 times the flow depth for a fairly wide range of simulated low river flow conditions. Rapid mixing was observed for all configurations provided that a critical momentum flux ratio (ratio of width-averaged ambient momentum flux to width-averaged effluent momentum flux) did not exceed a critical value which depends on the source Froude number (ratio of ambient velocity cubed to width-averaged buoyancy flux) in which case stratification tends to occur. In the thermal wedge investigation of the effectiveness of various types, configuration and combinations of structures such as sills, wind walls, and floating barriers for eliminating and/or suppressing the wedge were studied. The most promising arrangements consist of floating barriers located a short distance upstream from the diffuser pipe, and a combination of a sill and width contraction a short distance downstream from the diffuser pipe.
(*h*) **The Mixing Characteristics of Submerged Multiple-Port Diffusers for Heated Effluents in Open Channel Flow,** J. R. Argue, W. W. Sayre, *Iowa Inst. Hydr. Res. Rept. No. 147,* July 1973.
Prevention of Thermal Wedges Resulting from Multiple-Port Diffusers, A. Cardenas, *M.S. Thesis,* Univ. of Iowa, July 1973.

073-08038-050-20

TURBULENT JETS IN CROSS-FLOWS

(*b*) Office of Naval Research, Dept. of the Navy; The Marley Company.
(*c*) John F. Kennedy.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Experiments are being conducted in an open-throat wind tunnel using a control-box on the sides of the jet. Distributions of velocity and pressure are measured at the upstream and downstream ends of the box, in order to determine the entrainment of fluid and momentum by the jet up to any elevation. An integral-type analysis was developed to predict the trajectory, width, and velocity distribution.
(*f*) Completed.
(*g*) Experiments were conducted at a jet Reynolds number of about 2 x 10^5. The jet-to-cross-flow velocity ratio ranged from 2 to 9. Pressure distributions on the jet-exit plane and velocity distributions in the center plane were measured. Data on the drag force, jet trajectory, half-width, and center line velocity were obtained. A similarity form based on the analytical model was developed for the velocity distributions in the center plane. Measurements were made to determine the entrainment of mass and momentum into the jet from the cross-flow. It was found that the drag exerted on the jet in the vicinity of the exit plane is much greater than that on a rigid, circular cylinder. The

increase apparently is a result of the intense entrainment of fluid in the wake zone of the jet. At larger distances from the origin, the momentum transfer due to entrainment of ambient fluid is primarily responsible for the deflection of the jet. The rate type analysis was carried out for buoyant and nonbuoyant jets. The entrainment velocity was assumed to be a linear combination of two components, in the initial jet and cross-flow directions, of the characteristic relative velocity between the jet and the receiving fluid. The equations were solved in Cartesian coordinates for the near-field for both buoyant and nonbuoyant jets, and for the far-field for the nonbuoyant jets. The equations were solved in a natural coordinate system for the intermediate, curvilinear zone for the case of nonbuoyant jets. Drag force was taken into consideration in the analysis in the near field of the turbulent, nonbuoyant jet. For the trajectories of nonbuoyant jets in cross-flows, the analysis predicts a parabolic-logarithmic relation in the near field, and an elliptic-function relation in the intermediate zone, and a 1/3-power relation in the far field. The trajectories for round buoyant jets and buoyant slot jets in quiescent homogeneous fluids were found to be polynomials which can be approximated by the 1/3- and 2/5-power relations, respectively. The closed form solutions were verified by the experimental data obtained from the present and from previous investigations, as well as by numerical solutions developed by previous investigators.

(*h*) **Turbulent Nonbuoyant or Buoyant Jets Discharged into Flowing or Quiescent Fluids,** D. T. L. Chan, *Ph.D. Thesis*, Univ. of Iowa, July 1972.
Turbulent Nonbuoyant or Buoyant Jets Discharged into Flowing or Quiescent Fluids, T. L. Chan, J. F. Kennedy, *Iowa Inst. of Hydr. Res. Tech. Report No. 140*, Aug. 1972.
Submerged Buoyant Jets in Quiescent Fluids, D. T-L. Chan, J. F. Kennedy, *J. Hydr. Div., ASCE* **101,** HY6, June 1975, pp. 733-748.

073-08040-220-05

TURBULENT STRUCTURE OF SEDIMENT SUSPENSIONS

(*b*) Agricultural Research Service, U.S. Dept. of Agric., Oxford, Miss.
(*c*) Dr. C. Farell.
(*d*) Experimental and analytical; basic research and graduate thesis.
(*e*) Measurement of the turbulent velocity fluctuations in a sediment-laden flow and simultaneous measurement of the sediment-concentration fluctuations as a step towards the understanding of the mechanism by which sediment particles are entrained from the bed and carried into suspension, and for the verification of the Reynolds analogy employed for the transport of sediment.
(*f*) Completed.
(*g*) A two-dimensional, uniform, turbulent, open-channel, shear flow over a flat bed, which was just covered with quartz sand under the flow conditions utilized, was studied experimentally. A hot-wire anemometer and the Iowa Sediment Concentration Measuring System were employed for the measurement of velocities and suspended sediment concentrations. Governing equations were derived and the analysis of random data was considered in detail. It is shown that there is no internal wave-like motion in this flow. The contribution of energy from various eddy sizes to the fluctuations is shown by spectra. Finally, the similarity between the transport of the sediment and that of the momentum is established, supporting the use of the Reynolds analogy for the transport of sediment.
(*h*) **An Experimental Investigation of the Turbulent Structure of Sediment Suspensions,** V. Danushkodi, *Ph.D. Thesis*, Univ. of Iowa, May 1975.
Analysis of Velocity Fluctuations and Suspended Sediment Concentration Data in Open Channel Flow, V. Danushkodi, C. Farell, F. A. Locher, *IIHR Report* (in preparation), 1975.

073-08042-010-21

THICK BOUNDARY LAYERS NEAR THE TAIL OF BODIES OF REVOLUTION

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. V. C. Patel.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) To carry out an experimental and theoretical investigation of the thick turbulent boundary layer near the tail of a body of revolution and to develop procedures for the calculation of the interaction between the boundary layer, the wake and the external potential flow.
(*f*) Completed.
(*g*) The major results of this study are described in the publications listed below.
(*h*) **A Unified View of the Law of the Wall Using Mixing-Length Theory,** V. C. Patel, *Aeronautical Quarterly* **24,** pp. 55-70, 1973.
An Experimental Study of the Thick Turbulent Boundary Layer Near the Tail of a Body of Revolution, V. C. Patel, A. Nakayama, R. Damian, *Iowa Inst. Hydr. Res. Rept. No. 142*, 1973.
On the Equations of a Thick Axisymmetric Turbulent Boundary Layer, V. C. Patel, *Iowa Inst. Hydr. Res. Rept. No. 143*, 1973.
Measurements in the Thick Turbulent Boundary Layer Near the Tail of a Body of Revolution, V. C. Patel, A. Nakayama, R. Damian, *J. Fluid Mech.* **63,** pp. 345-367, 1974.
A Simple Integral Method for the Calculation of Thick Axisymmetric Turbulent Boundary Layers, V. C. Patel, *Aeronautical Quarterly* **25,** pp. 47-58, 1974.
Calculation of the Viscous Resistance of Bodies of Revolution, A. Nakayama, V. C. Patel, *AIAA, J. Hydronautics* **8,** pp. 154-162, 1974.
Viscid-Inviscid Interaction Due to the Thick Boundary Layer Near the Tail of a Body of Revolution, A. Nakayama, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1974.

073-08043-300-13

MECHANICS OF RIVER ICE JAMS

(*b*) Rock Island District, Corps of Engineers.
(*d*) Theoretical and experimental; basic and applied research; Masters and Doctoral theses.
(*e*) A coordinated theoretical and laboratory investigation of the mechanics of formation and evolution of ice jams in rivers. The project includes an experimental study of the compressive and shear strengths of floating, fragmented ice covers; an analytical and experimental investigation of the criteria for submergence of floes at the upstream end of an ice cover and their transport beneath the jam; an analytical model for prediction of the streamwise distributions of ice-cover thickness and flow depth, upstream rate of jam propagation, flow depth and ice and water discharges at the upstream end of the cover, and ice concentration distribution upstream from the jam.
(*g*) Approximate, analytical models for the compressive and shear strengths of floating, fragmented ice were developed. Both the limiting compressive and shear stresses are predicted to increase linearly with jam thickness. The experiments confirmed the analytical models for compressive and shear strengths to the extent possible, but indicate that the strengths are strongly strain-rate dependent. Compressive failure frequently occurs by buckling of the ice cover. Analytical curves were developed to predict the submergence of floes at the upstream end of the cover, and the results verified experimentally. Generally a larger velocity or Froude number is required to submerge the floes than to transport them beneath the cover. The analytical model gives a fairly complete prediction of the evolution and behavior of ice jams. The weakest aspect of the theory is the analytical expression it includes for the shear and compressive strengths of jammed ice.
(*h*) **Stability of Floating Ice Blocks,** M. S. Uzuner, *M.S. Thesis*, Univ. of Iowa, May 1971.

The Stability of Floating Ice Blocks, J. F. Kennedy, M. S. Uzuner, *J. Hyd. Div., Proc. ASCE* **98,** HY12, Dec. 1972.

Internal Shear Strength of Floating Fragmented Ice Covers, M. P. Merino, *M.S. Thesis,* Univ. of Iowa, May 1974.

Hydraulics and Mechanics of River Ice Jams, M. S. Uzuner, *Ph.D. Thesis,* Univ. of Iowa, May 1974.

Hydraulics and Mechanics of River Ice Jams, M. S. Uzuner, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 161,* May 1974.

073-08828-340-73

MOVABLE-BED HYDRAULIC MODEL STUDY FOR COOPER NUCLEAR STATION INTAKE SYSTEM

(*b*) Nebraska Public Power District.
(*c*) Dr. William W. Sayre.
(*d*) Experimental (laboratory); applied research, design.
(*e*) Model study to reduce amount of sediment taken into circulating- and service-water systems, and amount of sediment deposited in the intake structure.
(*f*) Completed.
(*g*) Seven different schemes, designed to reduce the amount of sediment entering the intake structure and circulating- and service-water systems by modifying the approaching flow, were investigated in this study. The best results were obtained with a combination training wall-skimming weir placed parallel to the face of the intake structure. A number of variations of this scheme were tested before arriving at an optimum configuration which satisfied the channel-encroachment constraint of the Corps of Engineers. The model results indicate that the configuration finally adopted should effect a 40 to 70 percent reduction in the amount of suspended sediment entering the circulating- and service-water systems, for the river flow conditions which prevail most of the time. A very large reduction in the amount of gravel entering the intake structure is also expected.
(*h*) **Movable-Bed Hydraulic Model Study for Cooper Nuclear Station Intake System,** Y. Onishi, W. W. Sayre, *Iowa Inst. of Hydr. Res. Rept. No. 156,* Mar. 1974.

073-08829-870-73

TRANSVERSE MIXING CHARACTERISTICS OF THE MISSOURI RIVER DOWNSTREAM FROM THE COOPER NUCLEAR STATION

(*b*) Nebraska Public Power District.
(*c*) Dr. W. W. Sayre.
(*d*) Field investigation; applied research.
(*e*) Field investigation with dye tracer to predict size and configuration of thermal plume from Cooper Nuclear Station.
(*f*) Completed.
(*g*) Rhodamine WT dye, introduced continuously into the plant once-through circulating-water system, was used to simulate the waste heat. Transverse profiles of dye concentration, depth, and velocity were obtained at several cross sections in the six-mile reach immediately downstream from the plant.

The results indicate that the excess temperature in the river at full plant load can be reduced by dilution to less than 5°F within a 45-acre mixing zone with the present discharge canal system, provided that the river discharge is not less than about 20,000 cfs. For lower river discharges, some additional mixing would be required to achieve the same reduction.

Based on a more detailed analysis of the transverse mixing process, the dimensionless transverse mixing coefficient in the six-mile reach downstream from the plant was found to have average and maximum values that are believed to considerably exceed any previously published values.
(*h*) **Transverse Mixing Characteristics of the Missouri River Downstream from the Cooper Nuclear Station,** W. W. Sayre, T. P. Yeh, *Iowa Inst. of Hydr. Res. Rept. No. 145,* Apr. 1974.

073-08830-870-73

FIELD TESTING OF DIFFUSER PIPE SYSTEM FOR DISCHARGING CONDENSER COOLING WATER AT QUAD CITIES NUCLEAR POWER STATION

(*b*) Commonwealth Edison.
(*c*) Dr. W. W. Sayre.
(*d*) Field investigation; applied research, operation; contributing toward Ph.D. thesis.
(*e*) Periodic temperature and velocity distribution measurements in the Mississippi River upstream and downstream from the diffuser pipe discharge system to ensure that the plant discharge is meeting the thermal standards of the Illinois Pollution Control Board and other concerned environmental protection authorities. Comparison of prototype performance with laboratory model predictions.
(*g*) The results of 24 field surveys obtained over a wide range of river flow and plant discharge conditions show that although the distribution of temperature rise over the river cross section is less even than predicted by the model, the thermal standards were easily met on all occasions. Differences between model and prototype performances are thought to be mainly due to the tendency of vertically distorted models to overpredict the rate of transverse mixing.
(*h*) Several limited-distribution progress reports to sponsor (not available in quantity). The final report will be available for general distribution.

073-08831-870-75

INVESTIGATION OF SURFACE-JET THERMAL OUTFALL FOR IATAN STEAM ELECTRIC GENERATING STATION

(*b*) Black and Veatch Consulting Engineers.
(*c*) Dr. William W. Sayre.
(*d*) Computational; design, operational.
(*e*) Preliminary feasibility investigation of a surface-jet thermal outfall system for discharging the condenser cooling water from the proposed Iatan Steam Electric Generating Station into the Missouri River.
(*f*) Completed.
(*g*) Hydrographic measurements by the U. S. Geological Survey show that the geometry of and distribution of flow in the river channel is favorable for a surface-jet scheme. Downstream temperature-rise distributions are predicted for surface jets discharging both at right angles and parallel to the ambient flow for selected river discharges. The prediction technique takes into account the properties of the ambient flow, including the mixing mechanisms, as well as those of the jet. The right-angle discharge is predicted to be superior in almost every respect. For one-unit operation at full plant load and a river discharge of 10,000 cfs, it is predicted that the 5°F temperature-rise isotherm would cover a horizontal area of less than 0.5 acres and the zone-of-passage wherein the temperature rise is less than 5°F exceeds 85 percent of the river flow.
(*h*) **Investigation of Surface-Jet Thermal Outfall for Iatan Steam Electric Generating Station,** W. W. Sayre, *Iowa Inst. of Hydr. Res. Rept.* (report to sponsor, not available in quantity), July 1974.

073-08832-870-73

THERMAL OUTFALL SYSTEM FOR DRESDEN NUCLEAR STATION

(*b*) Commonwealth Edison.
(*c*) Dr. W. W. Sayre.
(*d*) Laboratory model study, computational; applied research, design, operation; contributing to M.S. thesis.
(*e*) Laboratory model study to guide design of slot-jet thermal outfall system for discharging circulating water from Unit 1 and blowdown discharge from Units 2 and 3 of Dresden Nuclear Station. Development of monitoring criteria based on laboratory and field measurements. Frequency analysis of river discharge and temperature data to determine limitations on plant operating conditions necessary to achieve compliance with thermal standards of Illinois Pollution Control Board for various background environmental conditions.

(*h*) Progress reports to sponsor (not available for distribution).

073-08833-870-70

AQUATIC ECOLOGY AND MIXING CHARACTERISTICS OF BEAVER SLOUGH, MISSISSIPPI RIVER, NEAR CLINTON, IOWA

(*b*) E. I. DuPont deNemours and Co.
(*c*) W. W. Sayre.
(*d*) Field investigation; applied research.
(*e*) Field investigation to collect hydrographic and chemical data for evaluating environmental impact of present and improved systems for treating chemical wastes discharged into Beaver Slough from the DuPont Film Processing Plant at Clinton. Data includes detailed measurements of sulfate concentrations, pH, temperature, transverse velocity distribution, and bottom benthic samples in the region of the slough occupied by the plume, and background measurements upstream from the plant.
(*g*) Data collected but not evaluated yet.

073-08834-010-21

FURTHER STUDIES OF THE THICK AXISYMMETRIC TURBULENT BOUNDARY LAYER

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. V. C. Patel.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) To make a detailed experimental study of the turbulent boundary layer and the near wake of a low-drag body of revolution and develop better methods for the prediction of the flow in the tail region.
(*g*) A low-drag body of revolution has been designed and is being constructed.

073-08835-700-54

DEVELOPMENT AND EVALUATION OF A LASER DOPPLER VELOCIMETER SYSTEM FOR MEASURING FRAZIL ICE CONCENTRATIONS

(*b*) National Science Foundation.
(*c*) Dr. John R. Glover.
(*d*) Experimental, Master's thesis.
(*e*) This study investigates the suitability of an optical-electronic system for determining the concentration of frazil ice particles simultaneously with mean flow velocity.
(*f*) Completed.
(*g*) The performance of the frazil ice concentration measuring system was evaluated by making measurements in flows in which frazil ice was being formed. A record of concentration versus time was obtained and compared with a curve of the mass of ice present in the flow versus time. Results indicated that the system is capable of measuring frazil ice concentrations.
(*h*) **A Frazil Ice Concentration Measuring System Using a Laser Doppler Velocimeter**, C. Schmidt, R. Glover. *J. Hydraulic Research, IAHR* **13**, 3, 1975.

073-08836-700-11

INVESTIGATION OF THE OPERATING CHARACTERISTICS OF THE IOWA SEDIMENT CONCENTRATION MEASURING SYSTEM

(*b*) U. S. Army Corps of Engineers, Coastal Engineering Research Center.
(*c*) Dr. John R. Glover.
(*d*) Experimental.
(*e*) The manner in which the Iowa Sediment Concentration Measuring System (ISCMS) responds to a group of particles and to a single particle is presented. Specifically, problems with nonuniformities in the transducer field and problems created by inadequate frequency response are discussed.
(*f*) Completed.
(*g*) The instantaneous value of the ISCMS output cannot be correlated with the instantaneous suspended sediment concentration within the probe field. Direct correlation of the ISCMS output with other signals is not practical with the present instrument. The frequency response of the instrument limits the use of the ISCMS to flows with mean velocities less than one fps.
(*h*) **Investigation of the Operating Characteristics of the Iowa Sediment Concentration Measuring System**, F. A. Locher, J. R. Glover, T. Nakato, *IIHR Report No. 170*, Nov. 1974.

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Agricultural Engineering, Ames, Iowa 50010. Dr. H. P. Johnson, Professor.

074-0017W-810-07

PHYSICAL AND ECONOMIC ANALYSIS OF WATERSHEDS

See Water Resources Research Catalog **9**, 6.0339.

074-0264W-870-33

MOVEMENT OF PESTICIDES AND NUTRIENTS WITH WATER AND SEDIMENT AS AFFECTED BY TILLAGE PRACTICES

See Water Resources Research Catalog **9**, 5.0658.

074-0265W-840-07

QUALITY OF TILE EFFLUENT

See Water Resources Research Catalog **9**, 5.0659.

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Engineering Science and Mechanics, Ames, Iowa 50010. Professor Donald F. Young.

075-07392-270-40

EFFECT OF STENOTIC OBSTRUCTIONS ON FLOW IN TUBES

(*b*) Iowa State Univ. Engr. Research Inst.; National Institutes of Health.
(*d*) Experimental and theoretical; basic research.
(*e*) Project is concerned with steady and unsteady flow of liquids through circular tubes which contain some type of constriction. Flow characteristics which may be of importance to blood flow through arteries containing stenoses are being studied. These include pressure distribution, laminar separation phenomena, transition Reynolds numbers for the initiation of turbulence, and turbulence. Both *in vitro* and *in vivo* tests are under consideration.
(*h*) **Flow Characteristics in Models of Arterial Stenoses – Part 1, Steady Flow,** D. F. Young, F. Y. Tsai, *J. Biomechanics* **6**, pp. 395-410, 1973.

Flow Characteristics in Models of Arterial Stenoses – Part 2, Unsteady Flow, D. F. Young, F. Y. Tsai, *J. Biomechanics* **6**, pp. 547-559, 1973.

Resistance Characteristics of Arterial Stenoses, D. F. Young, N. R. Cholvin, *Proc. 10th Intl. Conf. on Med. and Biology*, p. 45, 1973.

Some In Vivo Measurements of Pressure Losses Across Arterial Stenoses, D. F. Young, N. R. Cholvin, A. C. Roth, *Proc. 27th Ann. Conf. Engr. in Med. and Biology*, p. 128, 1974.

An Integral Method for the Analysis of Flow in Arterial Stenoses, D. F. Young, B. E. Morgan, *Bull. Math. Biology* **36**, pp. 39-53, 1974.

Wall Vibrations Induced by Flow Through Modeled Arterial Stenoses, R. L. Kirkeeide, *M.S. Thesis*, Iowa State Univ., 1974.

Effect of Collateral and Peripheral Resistance on Flow Through Arterial Stenoses, A. C. Roth, *M.S. Thesis*, Iowa State Univ., 1974.

075-09020-000-00

OSCILLATING INCOMPRESSIBLE FLOW IN A TORUS

(*b*) Iowa State Univ. Engr. Research Institute.
(*c*) Dr. Bruce R. Munson.
(*d*) Theoretical, experimental; basic research.
(*e*) Investigation of the secondary flows within a coiled pipe or torus when the flow is driven by sinusoidal oscillations of the torus or by sinusoidal pressure gradient in a stationary torus. The qualitative and quantitative nature of the secondary flows generated are strongly dependent on the dimensionless frequency of oscillation.
(*g*) Secondary flow in an oscillating torus is directed from the outside of the bend toward the inside even at low frequencies of oscillation. This phenomenon is opposite to the outward centrifuging secondary flows for steady flow in a curved pipe or for flow driven by a slowly oscillating pressure gradient in a torus. Experimental results verify the perturbation theory solutions.

075-09021-000-00

FLOW IN A SPHERICAL ANNULUS

(*b*) Iowa State Univ. Engr. Research Inst.; National Science Foundation.
(*c*) Dr. Bruce R. Munson.
(*d*) Theoretical, experimental; basic research.
(*e*) Investigation of the basic laminar flow within the spherical annulus between two spheres rotating about a common axis. Investigation of the stability properties of spherical annulus flow and the transition to turbulence.
(*g*) Theoretical stability limits (critical Reynolds numbers) are obtained from linear hydrodynamic stability theory for the flow in a spherical annulus. Experimental and theoretical results show that the nature of transition from the basic laminar flow is strongly dependent upon various parameters of the flow – radius ratio, angular velocity ratio, etc. Experimental torque measurements are obtained for a wide range of Reynolds numbers – from Stokes flow to boundary layer flow.
(*h*) **Viscous Incompressible Flow Between Eccentric Coaxially Rotating Spheres,** B. R. Munson, *Phys. Fluids* **17**, 3, pp. 528-531, 1974.
Experimental Results for Low Reynolds Number Flow Between Eccentric Rotating Spheres, M. Menguturk, B. R. Munson, *Phys. Fluids* **18**, 2, pp. 128-130, 1975.
Viscous Incompressible Flow Between Concentric Rotating Spheres. Part 3: Linear Stability and Experiment, B. R. Munson, M. Menguturk, *J. Fluid Mech.*, in press.
Flow in a Spherical Annulus, M. Menguturk, *Ph.D. Dissertation*, Dept. of Mech. Engr., Duke Univ., July 1974.

075-09022-000-00

SELF EXCITED FLOW OSCILLATIONS

(*b*) Iowa State Univ. Engr. Research Institute.
(*c*) Dr. David K. Holger.
(*d*) Experimental and theoretical; basic research.
(*e*) Project is concerned with steady flow geometries in which the interaction between a free shear layer and solid boundary causes a periodic oscillation of the flow. Special applications of interest are pressure oscillations propagating into the surrounding fluid as sound and structural vibrations resulting from the flow solid boundary interaction.

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UNIVERSITY OF IOWA, IOWA INSTITUTE OF HYDRAULIC RESEARCH, see IOWA INSTITUTE OF HYDRAULIC RESEARCH

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JET PROPULSION LABORATORY, see CALIFORNIA INSTITUTE OF TECHNOLOGY

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THE JOHNS HOPKINS UNIVERSITY, Department of Earth and Planetary Sciences, Baltimore, Md. 21218. Professor O. M. Phillips.

076-08686-420-20

OCEAN SURFACE WAVES

(*b*) Fluid Mechanics Branch, Office of Naval Research.
(*d*) Theoretical and experimental.
(*e*) The dynamics of surface waves, including wave interactions, air-sea interactions and wave breaking.
(*h*) **On the Incipient Breaking of Small Scale Waves,** M. L. Banner, O. M. Phillips, *J. Fluid Mech.* **65**, 4, pp. 647-656, 1974.
Wave Breaking in the Presence of Wind Drift and Swell, O. M. Phillips, M. L. Banner, *J. Fluid Mech.* **66**, 4, pp. 625-640, 1974.

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UNIVERSITY OF KANSAS, School of Engineering and Architecture, Department of Civil Engineering, Lawrence, Kans. 66044. Professor Yun-Sheng Yu.

077-08048-370-61

HIGHWAY STORM DRAINS

(*b*) Kansas Water Resources Research Institute.
(*c*) Dr. J. S. McNown.
(*d*) Experimental and applied.
(*e*) A model inlet based on practice in the Kansas State Highway Commission was tested in laboratory to determine the distribution of flow in gutter and proportion of flow in gutter captured by the inlet for various slopes and discharges, and the effect of design modifications.
(*f*) Completed.
(*h*) **Balanced Storm Drainage,** J. S. McNown, C. H. Tai, *Contribution No. 94, Water Resour. Res. Inst. Univ. of Kansas*, 1972.

077-08049-210-00

UNSTEADY FLOW THROUGH A PIPE ORIFICE

(*d*) Theoretical and experimental; basic research for Doctoral thesis.
(*e*) Unsteady laminar flows through a pipe orifice due to a suddenly imposed constant pressure gradient and a time-dependent pressure gradient are investigated, respectively. Experiments on laminar oscillatory flow through a pipe orifice are also being conducted.
(*f*) Completed.
(*h*) **Pendulation of Liquid in Interconnected Tanks and Unsteady Flow Through an Orifice,** C. H. Tai, *Ph.D. Dissertation*, 1972.

077-08050-870-61

LOCALIZED THERMAL POLLUTION IN SHALLOW STREAMS

(*b*) Kansas Water Resources Research Institute.
(*d*) Experimental and theoretical.
(*e*) Laboratory experiments are conducted to determine the effect of thermal discharge into a shallow stream on its temperature distribution. Predictive method will be developed to determine the temperature distribution.
(*h*) **Temperature Distribution in a Thermal Plume,** Y. S. Yu, *Trans. 24th Ann. Conf. Sanitary Engrg.*, Feb. 6, 1974.

077-08051-870-73

BASELINE STUDY OF LA CYGNE LAKE, KANSAS

(*b*) Kansas City Power and Light Company and Kansas Gas and Electric Company.
(*c*) Y. S. Yu, P. Willhite, F. Cross, W. J. O'Brien.
(*d*) Experimental.
(*e*) A baseline study of the La Cygne Lake as a cooling lake for power generation is conducted by an interdisciplinary

team of staff members and students from the University of Kansas. The objectives are 1) to establish seasonal variation of temperature distribution, water quality, and biota prior to power plant startup; 2) to estimate the seasonal circulation pattern in lake; and 3) to predict the effects of future heated water discharges on 1) and 2).

(*f*) This project was extended for three more years under the sponsorship of the Office of Water Resources Research.

077-08768-370-60

HYDRAULIC DESIGN CURVES FOR KANSAS STANDARD DEPRESSED CURB INLETS

(*b*) Kansas Highway Commission and Federal Highway Administration.
(*d*) Experimental.
(*e*) Experiments were conducted on a 1:4 scale roadway model. Six inlet models were tested. Each inlet was tested on 33 different combinations of transverse and longitudinal slopes to determine the intercepted flow at various total discharges.
(*f*) Completed.
(*g*) Hydraulic design curves have been developed from the model data. A comparison of the hydraulic efficiency of these inlets is presented. Possible further improvements of the present design are recommended.
(*h*) **Hydraulic Design Curves for Kansas Standard Depressed Curb Inlets,** Y. S. Yu, R. D. Seitz, S. K. Kaul, *Final Report*, July 1974.

077-08769-870-61

THERMAL PLUMES IN THE KANSAS RIVER

(*b*) Kansas Water Resources Research Institute.
(*d*) Experimental and analytical.
(*e*) A study of velocity and temperature distributions in the heated discharge into the Kansas River between Lawrence and Topeka.

077-08770-870-33

PHYSICAL AND BIOLOGICAL EFFECTS OF THERMAL DISCHARGES AT LA CYGNE LAKE

(*b*) Office of Water Research and Technology and Kansas Water Resources Research Institute.
(*c*) Y. S. Yu, P. Willhite, F. Cross, W. J. O'Brien.
(*d*) Experimental, applied research.
(*e*) Same as that described in 077-08051-870-73, plus the study of the effects of the heated discharge during plant operation.

077-08771-420-00

WIND-GENERATED WAVES AND CURRENTS IN LA CYGNE LAKE

(*d*) Analytical and experimental.
(*e*) A study of wind-generated waves and currents in a relatively small lake.

UNIVERSITY OF KENTUCKY, College of Engineering, Department of Civil Engineering, Lexington, Ky. 40506. Professor Don J. Wood.

078-08053-830-00

STUDY OF MECHANICS OF GULLY FORMATION AND DEVELOPMENT AND ITS EFFECT ON SEDIMENT YIELD

(*b*) Office of Water Resources Research.
(*c*) Dr. T. Y. Kao.
(*d*) Analytical and experimental; applied research.
(*e*) Study of the basic mechanics of gully erosion and flow in gully channels under simulated conditions.
(*f*) Partial completion.
(*h*) **Laboratory Simulation of Rainfall Erosivity for Gully Formation Study,** T. Y. Kao, *Res. Rept. No. 73*, Univ. of Ky., Water Resour. Res. Inst., Lexington, Ky.

Spatially Varied Subcritical and Supercritical Flow in Gullies, T. Y. Kao, *Res. Rept. No. 74*, Univ. of Ky., Water Resour. Res. Inst., Lexington, Ky.

078-08054-040-00

HYDRODYNAMIC DRAINAGE DUE TO IMPACT MOTION

(*c*) Dr. T. Y. Kao.
(*d*) Analytical and experimental, basic and applied research.
(*e*) Study of the flow characteristics and pressure distribution due to impact of a given shape rigid plate lying on the surface of a liquid of finite depth.
(*g*) Potential flow model yields a closed form solution which provides a time dependent pressure with a magnitude greater than the experimentally measured data. The result computed from the solution of the dynamic wave equation agree closely with that obtained from characteristic method. More experimental data will be obtained in the laboratory for further comparison.

078-08688-130-33

HYDRODYNAMIC SEPARATION OF SOLIDS FROM SOLID LIQUID MIXTURES

(*b*) Office of Water Research and Technology.
(*d*) Analytical and experimental; applied research for Doctoral thesis.
(*e*) Various hydrodynamic means of separating solids from liquids are being investigated analytically and experimentally.

078-08689-130-82

TRANSPORT OF COAL USING COAL SLURRY PIPELINES

(*b*) Institute for Mining and Minerals Research.
(*c*) Dr. T. Y. Kao and Dr. D. J. Wood.
(*d*) Analytical and experimental, applied research.
(*e*) All aspects of coal haulage using slurry pipelines are being investigated. A coal collection and transportation system for eastern Kentucky is being proposed. Start-up and shutdown conditions are being investigated.
(*h*) **Incipient Motion of Solids in Solid-Liquid Transport Systems,** T. Y. Kao, D. J. Wood, *Trans. AIME* **255,** Mar. 1974.

078-08690-860-00

ANALYSIS OF WATER DISTRIBUTION SYSTEMS

(*b*) Office of Continuing Education, College of Engineering, University of Kentucky.
(*d*) Analytical, development of computer model.
(*e*) A computer program for steady state analysis of pressure and flow in liquid flow systems was developed using a new method of analysis. The model incorporated such components as storage tanks, pumps, valves, check valves, and pressure regulators. Analytical procedure has excellent convergence characteristics.
(*f*) Completed; efforts continuing to make program available to engineers.
(*h*) **Users Manual – A Computer Program for the Analysis of Pressure and Flow in Pipe Distribution Systems,** D. J. Wood, Office of Continuing Education, College of Engrg., Univ. of Ky., 1974.

078-08691-220

SEDIMENT FILTRATION CAPACITY OF GRASSED AREAS

(*b*) Office of Water Research and Technology.
(*c*) Dr. B. J. Barfield and Dr. T. Y. Kao.
(*d*) Analytical and experimental, applied research.
(*e*) By using a probabilistic approach to analyzing the movement of suspended sediment through a grass media, a model was developed of the trapping efficiency of grass as a function of flow velocity, depth of flow, spacing and full velocity of the sediment. The model was calibrated for a rigid medium and is presently subject to the test for its application to flexible simulated grass in a laboratory research flume.

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY of Columbia University, Palisades, N. Y. 10964. Dr. Manik Talwani, Director.

079-08827-450-52

TRANSPORT AND TRANSFER RATE IN THE WATERS OF THE CONTINENTAL SHELF

(*b*) U. S. Energy Research and Development Administration.
(*c*) Robert Gerard, Senior Research Associate.
(*d*) The investigations under this project pertain to problems of mixing, diffusion and circulation in the New York Bight region. Field studies of a basic scientific nature are regularly conducted which will lead to improved models of circulation and transfer processes for waters of the Continental Shelf.
(*e*) Long-term observations of currents, turbidity, and bottom water transport in the Hudson Submarine Channel are routinely made. STD stations are made along transects across the Continental Shelf and large volume water samples are obtained for analyses of radioactive tracers (radium and thorium) in the waters of the New York Bight.
(*f*) Active through Summer 1975.
(*h*) **A 54-day Record of Currents and Suspended Material in the Hudson Canyon,** A. F. Amos, T. N. Baker, S. Daubin, S. Eittreim.
The Geochemistry of Radium and Thorium, H. Feely.
Geochemical Studies of Mixing on the Shelf and Upper Continental Slope: New York Bight, P. Biscaye, G. Mathieu, R. Hesslein, D. Hammond, C. Olsen, *Proc. 7th Ann. Long Island Sound Conf.*, Univ. Inst. of Oceanog., City Univ. of New York, Jan. 11, 1975.

LEHIGH UNIVERSITY, Department of Mechanical Engineering and Mechanics, Bethlehem, Pa. 18015. Professor J. A. Owczarek.

081-08062-600-20

FLUID AMPLIFIERS

(*b*) Office of Naval Research.
(*d*) Experimental and theoretical; basic and applied research for thesis (Master's or Doctoral).
(*h*) **A Study of Flow Fields in Bistable Fluid Amplifiers, Part 1: Experimental Investigation,** W. B. Wagner, J. A. Owczarek, *Tech. Rept. No. 9*, Lehigh Univ., June 1972 (AD751627).
A Study of Flow Fields in Bistable Fluid Amplifiers, Part 2: Analytical Investigation, W. B. Wagner, J. A. Owczarek, *Tech. Rept. No. 10*, Lehigh Univ., June 1972 (AD751606).
Design and Analysis of a Proportional Fluid Amplifier, K. C. Heck, J. P. Ries, *Tech. Rept. No. 11*, Lehigh Univ., July 1972 (AD751457).
Experimental Study and Analog Simulation of a Jet Interaction Type Proportional Fluid Amplifier, S. Y. Rehmani, J. P. Ries, *Tech. Rept. No. 12*, Lehigh Univ., July 1972 (AD751458).
Measurements of Turbulent Velocity Fluctuations in a Confined Jet with Application to Fluid Amplifier Design, R. G. Sarubbi, S. M. Patel, *Tech. Rept. No. 13*, Lehigh Univ., July 1972 (AD752041).
Flow Fields in Wall Jet Receivers with Right Angle Spill Flow at the Entrance, S. J. Bach, D. O. Rockwell, *Tech. Rept. No. 14*, Lehigh Univ., Feb. 1973 (AD759796).
Visualization of Secondary Flows in Planar Nozzles, J. A. Owczarek, A. N. Siddiqui, *Tech. Rept. No. 15*, Lehigh Univ., May 1973 (AD762743).
Design of a Near-Optimal Fluidic Operational Amplifier, F. T. Brown, J. S. Boparai, T. M. Sheikh, *Tech. Rept. No. 16*, Lehigh Univ., June 1973 (AD767667).
Interaction of Two Perpendicular Bounded Jets, Y. S. Cha, J. A. Owczarek, *Tech. Rept. No. 17*, Lehigh Univ., Aug. 1973 (AD767668).
Wall Jet Receiver Flow Field, H. S. Shen, D. O. Rockwell, *Tech. Rept. No. 18*, Lehigh Univ., Aug. 1973 (AD768882).
Laminar Flow in a Two-Dimensional Channel with a Right Angle Corner, R. M. Wilson, J. A. Owczarek, *Tech. Rept. No. 19*, Lehigh Univ., Aug. 1973 (AD768881).
Flow Through a Sudden Enlargement Subjected to Large Amplitude Low Frequency Axial Oscillations, D. Rockwell, N. Siddiqui, S. Rehmani, *Tech. Rept. No. 20*, Lehigh Univ., Aug. 1973 (AD770581).
Final Technical Report, J. A. Owczarek, Project Director, *Tech. Rept. No. 21*, Lehigh Univ., Aug. 1973 (AD770582).

LOCKHEED MISSILES AND SPACE COMPANY, INCORPORATED, Lockheed Ocean Laboratory, 3380 North Harbor Drive, San Diego, Calif. 92101. Dr. A. J. Carsola, Acting Ocean Sciences Department Manager.

082-09773-700-00

EVALUATION OF WATER QUALITY AND POLLUTION SENSORS

(*c*) Dr. H. Chin and Mr. J. C. Roque.
(*d*) Operation.
(*e*) The design characteristics and unattended reliability of Hydrolab Surveyor Model 6D, Delta Series 8018 DO Analyzer, Martek XMS Transmissometer and Comex MK IV Current Meter were evaluated under the fouling conditions in San Diego Bay.

082-09774-460-00

EVALUATION OF TURBULENT FLUXES NEAR THE AIR-SEA INTERFACE

(*c*) Dr. H. Chin.
(*e*) Three files of 1/2-5 and 16-5 measurements of wind speeds and directions and air and water temperatures in the Gulf of Mexico were analyzed in order to evaluate the magnitudes and directions of the heat fluxes near the interface under non-stable atmospheric conditions.
(*g*) The recovered data demonstrated considerable mesoscale variability in the thermal fields. The flux calculations illustrated patterns of both vertical and lateral divergences and convergences. Gusts to almost 30 m/s were recorded before the data buoy system was virtually blown apart.

082-09775-450-00

THERMAL TRANSPORT MODEL

(*c*) D. P. Hamm.
(*d*) Development.
(*e*) A computerized, finite difference, numerical model to simulate the heat budget in a three-dimensional bounded region of the ocean was developed for an IBM 360/91. A simulated outfall introduced heated water into the study region. The model predicted future states of the region by accounting for advection, diffusion and surface heat losses.
(*g*) Two outfall areas were simulated. The first was a 25 x 28 x 6 grid test case. The second was a 38 x 47 x 6 grid simulation of the outfall of the San Onofre Nuclear Generating Station in southern California.

LOS ALAMOS SCIENTIFIC LABORATORY of The University of California, Group T-3, P. O. Box 1663, Los Alamos, N. Mex. 87544. C. W. Hirt, Group Leader.

083-09014-640-54

NUMERICAL ANALYSIS OF TORNADO WIND LOADS ON BUILDINGS

(*b*) National Science Foundation.

(*c*) Leland R. Stein.
(*d*) Theoretical; applied research.
(*e*) Three-dimensional calculations are being performed on high-speed computers to accomplish verification that steady-state calculations of wind stresses agree with wind tunnel results; examination of the pressure history on a structure when a unidirectional wind varies suddenly in speed; and examination of the effects of a wind that varies rapidly in direction, perhaps simultaneously changing its strength, on a structure whose yield stress is changing as a result of the integrated effects.
(*g*) Three-dimensional steady-state calculations of wind-produced stresses on simple structures agree well with wind tunnel data.
(*h*) **Wind Loading on Buildings From the Lubbock Storm of 11 May 1970,** F. H. Harlow, Mar. 1974.
Structural Analysis of Tornado-Like Vortices, F. H. Harlow, R. Stein, *J. Atmos. Sci.* **31,** pp. 2081-2098, Nov. 1974.
Numerical Solution of the Flow Structure in Tornado-Like Vortices, L. R. Stein, F. H. Harlow, *LA-5713-MS* Los Alamos Scientific Lab., Los Alamos, N. Mex. 87544, Sept. 1974.

083-09015-130-00

NUMERICAL CALCULATIONS OF THREE-DIMENSIONAL FLUID FLOWS AND PARTICULATE TRANSPORT IN CURVED AND BIFURCATING PASSAGEWAYS

(*c*) William E. Pracht.
(*d*) Theoretical research.
(*e*) Detailed studies of the complex three-dimensional flow patterns and aerosol distributions in arbitrarily curved and bifurcated tubes of various cross sections are under way to determine the fluid dynamic parameters pertinent to aerosol transport and deposition. These studies make use of a newly developed numerical technique for solving the full three-dimensional transient dynamics of an incompressible fluid contained within arbitrarily shaped or moving boundaries. Emphasis is twofold: to examine the effects of flow profiles near curves and bifurcations on aerosol transport; and to study the manner in which particle motions and deposition patterns may depend upon particle size and density. The specific aim of the research is to provide a realistic and flexible capability to aid in the analysis and evaluation of inhalation hazards.
(*h*) **Calculating Three-Dimensional Fluid Flows at All Speeds With an Eulerian-Lagrangian Computing Mesh,** W. E. Pracht, *J. Comp. Phys.* **17,** pp. 132-159, 1975.
Particulate Transport in Three-Dimensional Fluid Flows Through Curved and Bifurcated Vessels, W. E. Pracht, *Proc. 1975 Summer Computer Simulation Conf.*, San Francisco, Calif., July 1975.

083-09016-270-52

NUMERICAL STUDY OF PULSATILE FLOW IN ARTERIES

(*b*) Energy Research and Development Administration.
(*c*) Bart J. Daly.
(*d*) Theoretical; applied research, development.
(*e*) A numerical procedure is being developed for the purpose of studying the pulsatile flow of blood through distensible arteries, utilizing a computational method that permits virtually arbitrary and time-varying boundary configurations. The technique development has concentrated on the effective simulation of two crucial characteristics of blood flow in large arteries: a nonisotropic and space-varying elastic model of distensible arteries, and an efficient procedure for calculating pulsatile flow.
(*g*) A study has been made of pulsatile flow through stenosed canine femoral arteries for lumen constrictions in the range 0-61 percent. Quantitative measurements of the pressure drop across the stenosis, the peak wall shear, and the development of local flow reversal in the wake of the stenosis are presented. Comparisons with *in vivo* measurements are made wherever possible.
(*h*) **A Numerical Study of Pulsatile Flow Through Constricted Arteries,** B. J. Daly, *Proc. 4th Intl. Conf. Numerical Methods in Fluid Dynamics*, Univ. Colo., Boulder, Colo., June 1974, Springer-Verlag.
A Numerical Study of Pulsatile Flow Through Stenosed Canine Femoral Arteries, submitted for publication.

083-09017-870-36

AIR POLLUTION TRANSPORT IN STREET CANYONS

(*b*) Environmental Protection Agency.
(*c*) Robert S. Hotchkiss.
(*d*) Theoretical; applied research.
(*e*) Research was conducted to demonstrate the applicability of numerically modeling the transport of pollution in street canyons. The numerical model employs the solutions of the fully nonlinear, three-dimensional Navier-Stokes equations along with a transport equation for pollutants, for regions of space in which obstacles or buildings cause strong distortions in the flow fields. The numerical technique is used to model three-dimensional flows for which some experimental data have been obtained. This includes calculating the distribution of pollutants in the Broadway Street Canyon in downtown St. Louis, Missouri. Also, the numerical method is used to calculate pollutant distributions in a non-specific street canyon; that is, a street canyon in which the geometry and other important non-dimensional flow parameters give rise to solutions that are applicable, in a general sense, to a variety of street canyons.
(*f*) Suspended.
(*h*) **The Numerical Calculation of Three-Dimensional Flows of Air and Particulates About Structures,** R. S. Hotchkiss, *Proc. Air Pollution, Turbulence and Diffusion Symp.*, Las Cruces, N. Mex., Dec. 7-10, 1971.
Particulate Transport in Highly Distorted Three-Dimensional Flow Fields, R. S. Hotchkiss, C. W. Hirt, *Proc. Summer Simulation Conf.*, San Diego, Calif., June 14-16, 1972.
Air Pollution Transport in Street Canyons, R. S. Hotchkiss, F. H. Harlow, *Environmental Protection Agency Rept. EPA-R4-029*, June 1973.
The Numerical Modeling of Air Pollution Transport in Street Canyons, R. S. Hotchkiss (submitted for publication to Atmospheric Environment).

083-09260-740-20

NUMERICAL STUDY OF FREE SURFACE FLOWS PAST CURVED, RIGID BOUNDARIES

(*b*) Office of Naval Research, Fluid Dynamics Program.
(*c*) B. D. Nichols.
(*d*) Theoretical; applied research; development.
(*e*) Numerical methods are being developed to calculate in three dimensions the transient dynamics of free surface flows past arbitrarily shaped bodies. A finite difference technique has been completed that calculates low amplitude, three-dimensional flow past obstacles that may be partially or completely submerged. A two-dimensional technique in which curved rigid and free boundaries are treated has also been developed. Several schemes to define the rigid and free surfaces have been developed, including a surface height function, Lagrangian particles, and a volume fraction function.
(*g*) A numerical technique has been developed for calculating three-dimensional, transient dynamics of incompressible fluid having a free surface. The Navier-Stokes equations are solved by a solution algorithm based on the Marker-and-Cell method. The flow may be calculated around variously shaped and spaced obstacles that are fully submerged or penetrate the surface. In addition, a similar two-dimensional technique has been developed with curved rigid and free surfaces as boundaries.
(*h*) **Calculating Three-Dimensional Free Surface Flows in the Vicinity of Submerged and Exposed Structures,** B. D. Nichols, C. W. Hirt, *J. Comp. Phys.* **12,** 2, pp. 234-246, June 1973.

SOLA – A Numerical Solution Algorithm for Transient Fluid Flows, C. W. Hirt, B. D. Nichols, N. C. Romero, *Los Alamos Scientific Lab. Rept. LA-5852*, Apr. 1975.

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LOUISIANA STATE UNIVERSITY AND A & M COLLEGE, School of Engineering, Baton Rouge, La. 70803.

084-05711-820-61

STORAGE OF FRESH WATER IN HORIZONTAL SALINE AQUIFERS – A MULTI-WELL SYSTEM

(*b*) La. Water Resources Research Institute.
(*c*) Dr. O. K. Kimbler, Prof., Dept. of Pet. Engrg. and Mr. R. G. Kazmann, Prof., Dept. Civil Engineering.
(*d*) Theoretical and experimental.
(*e*) A computational model to describe the operation and recovery efficiency of a multi-well system of injection/production wells is now available. The concept of irrecoverable "cushion water" was found to be essential in planning such a project. The mathematical model was verified by a series of tests on a miniature, laboratory-size, aquifer using a wide variety of density difference, injection rates, storage times, and production rates. The computational program yields recovery efficiencies that are invariably from four to eight percent lower than those observed.
(*f*) Completed, 1974.
(*h*) Report in preparation, to be published as *Bulletin 10* of the Louisiana Water Resources Research Institute.
Saline Aquifers – Future Storage for Fresh Water?, O. K. Kimbler, R. G. Kazmann, W. R. Whitehead, *Underground Waste Management and Artificial Recharge* **1**, Amer. Assoc. Petroleum Geologists, Tulsa, Okla., 1973. Reprint available from Director, La. Water Resour. Res. Inst., 146 Engrg. Drawing Bldg., La. State Univ., Baton Rouge, La. 70803.

084-08066-820-61

EFFECT OF FORMATION DIP, NATURAL FLUX, AND FORMATION STRATIFICATION ON CONFIGURATION OF FRESH WATER STORED IN SALINE AQUIFERS

(*b*) La. Water Resources Research Institute.
(*c*) Dr. O. K. Kimbler, Prof., Dept. of Pet. Engineering.
(*d*) Theoretical and experimental.
(*e*) A mathematical model that incorporates diffusion, dispersion, gravitational effects, and flux for a single-well system in a dipping aquifer has been tested experimentally in a miniature, laboratory-size, aquifer. Both experimental and calculated results indicated that, where present, pre-existing groundwater movement could be extremely detrimental to the water storage project, no matter how small the dip angle.
(*f*) Completed.
(*g*) A study has shown that it is theoretically possible to negate the effect of groundwater movement through the use of bounding wells to create an area of stagnation in the aquifer that can be used for water storage. A computer program has been devised to determine well capacity (either injection or production) when as few as eight well locations are specified. At least one well should be in each quadrant and the resulting system is balanced, i.e., requires no additional fluid for injection nor does it produce excess fluid for disposal.
(*h*) **Management of Waste Fluids in Salaquifers,** R. G. Kazmann, O. K. Kimbler, W. R. Whitehead, *J. Irrig. and Drainage Div, ASCE* **100,** IR4, Proc. Paper 10991, pp. 413-424, Dec. 1974.

084-08067-800-61

DIVERTING MISSISSIPPI RIVER WATER TO TEXAS – A PRELIMINARY EVALUATION OF PLANS

(*b*) La. Water Resources Research Institute.
(*c*) R. G. Kazmann, Prof., Dept. of Civil Engineering.
(*d*) Theoretical.
(*e*) See WRRC **6**, 8.0318.
(*f*) Completed.
(*g*) Various rates of diversion to Texas were incorporated in computer playbacks of the daily Mississippi River discharges at Vicksburg for the period from 1928 to 1967. Along with certain constraints was the assumption that the Old River Control Structure also diverted 25 percent of the flow into the Atchafalaya River at the same time. Salt-water encroachment in the river at New Orleans (Algiers) during low water would not have been significantly more frequent than it was under true past conditions if the minimum diversion rate to Texas had been 24,000 cfs for 8.5 months per year (total annual quantity, 12 million acre-feet). Estimates for the project include construction of new reservoirs in Texas to store 15 million acre-feet for seasonal distribution; 12,000 megawatts of electric power to lift the water 4,000 feet; and a total cost of irrigation water ranging from approximately $70 to $100 per acre-foot. Possible future projects in the Mississippi River basin, including proposed navigation improvements and reconstruction of the Old River Control Structure, would lead to greater diversion rates for shorter periods and, thus, higher project and water costs. A simple program forecasts the daily discharges at Vicksburg (up to six days) and New Orleans (up to nine days) from daily readings at upstream gaging stations. The estimates are within 11 percent of recorded flows at least 80 percent of the time. Salt-water advance up the Mississippi can also be reliably predicted with a subroutine from either the actual or the forecast flows.
(*h*) **The Mississippi River – A Water Source for Texas? (Evaluation of a Proposed Water Diversion),** R. G. Kazmann, O. Arguello, *Louisiana Water Resour. Res. Inst. Bull. 9*, La. State Univ., Baton Rouge, La., Mar. 1973.
Mississippi River Water for Texas?, O. Arguello, R. G. Kazmann, *J. Irrig. and Drainage Div., ASCE* **99,** IR4, Proc. Paper 10212, pp. 441-448, Dec. 1973.
Both publications available from Director, Louisiana Water Resour. Res. Inst., Rm. 146, Engrg. Drawing Bldg., La. State Univ., Baton Rouge, La. 70803.

084-08692-070-61

PHYSICAL STUDIES OF ANISOTROPIC MEDIA WITH APPLICATIONS TO GROUNDWATER AND WASTE DISPOSAL PROBLEMS

(*b*) La. Water Resources Research Institute.
(*c*) Dr. W. R. Holden, Prof., Dept. Pet. Engineering.
(*d*) Theoretical and experimental; applied research.
(*e*) Develop electrical analog of two-dimensional, steady state, single fluid flow in formations possessing hydraulic conductivities that are sensitive to flow direction, and to devise quantitative procedure to determine magnitude and orientation of maximum and minimum conductivity using whole core permeameter.
(*f*) Completed.
(*g*) Electrical analog developed to simulate anisotropic media; whole core permeameter study only partially successful in that mathematical analog to simulate observed results was not satisfactory due to inability to completely specify boundary conditions at entrance and exit of permeameter.

084-08693-820-61

EFFECT OF VISCOSITY RATIO ON THE RECOVERY OF FRESH WATER STORED IN SALINE AQUIFERS

(*b*) La. Water Resources Research Institute.
(*c*) Dr. O. K. Kimbler, Prof., Dept. of Pet. Engineering.
(*d*) Experimental and theoretical, applied research.
(*e*) The dispersivity changes due to differences between the viscosity of the injected and native fluid are to be studied experimentally. The results will be used in existing mathematical models to compute recovery efficiency of water storage projects. The computed results will be compared with the results of experiments using the same parameters.

084-08694-820-61

THE STORAGE OF FRESH WATER IN SALINE AQUIFERS – THE EFFECT OF AQUIFER DIP ON THE EFFICIENCY OF A MULTI-WELL SYSTEM

(*b*) La. Water Resources Research Institute.
(*c*) Prof. R. G. Kazmann, Dept. Civil Engrg.; Dr. O. K. Kimbler, Prof., Dept. Pet. Engineering.
(*d*) Theoretical and experimental.
(*e*) See WRRC **9**, 4.0124.
(*h*) **Waste Surveillance in Subsurface Disposal Projects,** R. G. Kazmann, *Ground Water*, Nov.-Dec. 1974.

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MARTIN MARIETTA CORPORATION, Martin Marietta Laboratories, 1450 South Rolling Road, Baltimore, Md. 21227. Dr. Albert C. Westwood, Director of MML.

085-08069-010-26

AERODYNAMICS-BOUNDARY LAYER

(*b*) Air Force Office of Scientific Research (in part); Army Research Office – Durham (in part).
(*c*) Dr. K. C. Wang.
(*d*) Theoretical; applied research.
(*e*) Development of numerical methods for exact calculations of three-dimensional laminar boundary layers and to examine thereby the nature of such viscous flows, and in particular to study laminar flow near separation.
(*g*) Exact solutions have been obtained for the three-dimensional, incompressible, laminar boundary layer over an ellipsoid of revolution at low, high and extremely high incidences and with and without spinning about its major axis.
(*h*) **Boundary Layer Over a Blunt Body at High Incidence with an Open-Type of Separation,** K. C. Wang, *Proc. Soc. London A*. **340**, pp. 33-55, Sept. 1974.
Laminar Boundary Layer Over a Body of Revolution at Extremely High Incidence, K. C. Wang, *Phys. of Fluids* **17**, 7, pp. 1381-1385, July 1974.
Laminar Boundary Layer near the Symmetry-Plane of a Prolate Spheroid, K. C. Wang, *AIAA J.* **12,** 7, pp. 949-958, July 1974.

085-08070-540-26

LIFTING AERODYNAMIC SYSTEM

(*b*) Air Force Office of Scientific Research (in part).
(*c*) Dr. P. F. Jordan.
(*d*) Theoretical; applied research.
(*e*) Review of the methods of steady and unsteady lifting surface analysis to obtain better engineering analytical methods.
(*g*) An exact lifting surface solution has been found and generalized.
(*h*) **Exact Solutions for Lifting Surfaces,** P. F. Jordan, *AIAA J.* **11,** pp. 1123-1129, Aug. 1973.
Structure of Betz Vortex Cores, P. F. Jordan, *AIAA J. of Aircraft* **10**, pp. 691-693, Nov. 1973.
On Lifting Wings with Parabolic Tips, P. F. Jordan, *ZAMM* **54**, pp. 463-477, Aug. 1974.

085-08695-870-60

PLUME RISE AND DISPERSION MODELS FOR STACK EMISSIONS

(*b*) Maryland Department of Natural Resources.
(*c*) Dr. J. C. Weil.
(*d*) Theoretical and field investigation; applied research.
(*e*) Development of simple analytical models for predicting the rise and dispersion of heated stack and cooling tower emissions, the effect of these emissions on air quality, and testing of the models with field data around large fossil-fueled power plants.
(*g*) A Gaussian plume model has been tested at two power plants to determine the best method for estimating plume dispersion and to evaluate the overall accuracy of the model in predicting pollutant ground-level concentrations. A model has been developed to predict the rise of moist plumes and a simple analytical result obtained for the case of rise in a saturated atmosphere.
(*h*) **Measured vs Predicted Plume Dispersions at the Chalk Point and Dickerson Power Plants,** J. C. Weil, *Maryland Power Plant Siting Program Rept. PPSP-MP-8*, Apr. 1973.
Comparison Between Measured and Model-Estimated Ground-Level SO_2 Concentrations Downwind from the Dickerson Power Plant, J. C. Weil, *Maryland Power Plant Siting Program Rept. PPSP-MP-11*, Apr. 1974.
Preliminary Analysis of Chalk Point Air Plume Data (September 1973 to February 1974), J. C. Weil, *Interim Rept. Maryland Power Plant Siting Program*, June 1974.
The Rise of Moist, Buoyant Plumes, J. C. Weil, *J. Appl. Meteor.* **13**, pp. 435-443, June 1974.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Civil Engineering, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Cambridge, Mass. 02139. Donald R. Harleman, Laboratory Director.

Requests for reprints and reports should be addressed to Professor Donald R. F. Harleman, Laboratory Director, Room 48-311, M.I.T.

086-05544-440-00

THERMAL STRATIFICATION AND WATER QUALITY IN LAKES AND RESERVOIRS

(*b*) Environmental Protection Agency (Water Quality Office).
(*c*) Professor D. R. F. Harleman.
(*d*) Experimental and analytical; basic research (Doctoral thesis).
(*e*) Development of mathematical models for the prediction of the seasonal distribution of temperature and water quality parameters in lakes and reservoirs with horizontal stratification.
(*g*) A mathematical model has been developed which predicts the yearly cycle of temperature distribution within a reservoir and the outlet water temperature. The model accounts for heat input from inflowing streams, solar radiation, heat output from evaporation, radiation and at the reservoir outlet. The mathematical model was verified by comparison with temperature observations in a laboratory reservoir having artificial insolation and with field data for Fontana and Flaming George Reservoirs. A water quality model has been coupled with the temperature distribution model to predict the distributions of conservative and non-conservative substances.
(*h*) **A Predictive Mathematical Model for the Behavior of Thermal Stratification and Water Quality of Flaming George Reservoir, Utah-Wyoming,** D. B. Adams, *S.M. Thesis*, M.I.T., Dept. Civil Engrg., May 1974.

086-06413-420-20

SURFACE WAVE STUDIES

(*b*) Office of Naval Research, Dept. of the Navy.
(*c*) Professor C. C. Mei.
(*d*) Theoretical; basic research (Master's and Doctoral theses).
(*e*) Topographical effects on coastal currents and harbor oscillations.
(*g*) When the shoreline topography is not simple, refraction changes the wave intensity and hence the averaged wave momentum. In the breaking zone, this changes the driving force for steady currents. Theoretical models are being developed for currents around an island or a headland. For harbors with varying depth, waves may be trapped near shallow edges. Excitation of these trapped waves due to incident tsunamis is being studied. Nonlinear effects due to separation loss at the entrance and to large amplitudes are also studied.

(*h*) **Quadratic Loss and Scattering of Long Waves,** C. C. Mei, P. L. F. Liu, A. T. Ippen, *J. Waterways, Harbors and Coastal Engrg. Div. ASCE* **100,** Aug. 1974.
Effects of Entrance Loss on Harbor Oscillations, U. Unluata, C. C. Mei, *J. Waterways, Harbors and Coastal Engrg. Div. ASCE* **101,** WW2, May 1975.

086-8076-870-75

SUBMERGED DIFFUSERS FOR THERMAL DISCHARGES IN COASTAL WATERS

(*b*) Stone and Webster Engrg. Corporation and Long Island Lighting Company.
(*c*) Professor D. R. F. Harleman and Dr. G. H. Jirka.
(*d*) Experimental and theoretical; basic and applied research (Doctoral thesis).
(*e*) Design and prediction of the near-field temperature distribution for submerged, multi-port diffusers in coastal waters. Temperature criteria prescribe a maximum temperature rise of 1-1/2 °F at the water surface. Studies are concerned with two power plant sites on the north shore of Long Island, the proposed Shoreham Nuclear Power Station and the expansion of generating capacity at the Northport Station.
(*f*) Completed.
(*g*) Undistorted models of the Shoreham Station at scales of 1/20 and 1/100 were tested to determine near-field temperature distributions for two- and three-dimensional multi-port diffuser configurations in shallow (15-20 ft) water. Vertical temperature profiles indicated that fully mixed conditions were obtained downstream of the diffuser. The diffusers were tested under various steady and unsteady currents in the receiving water to simulate the effect of the changing magnitude and direction of the prototype tidal currents.
The experimental investigation of the Northport Station was conducted in two parts. First, a two-dimensional study of the basic characteristics of submerged multi-port diffusers with varying crossflow magnitudes was undertaken. Results were used to obtain a preliminary design. Second, a site model at a scale of 1/100 was tested under a variety of tidal conditions investigating three-dimensional effects of the diffuser discharge.
A theoretical and experimental study of the mechanics of multi-port diffusers for thermal discharges was carried out concurrently. The study was aimed at the structure of heated discharge in the vertical plane and at horizontal circulations induced. Results indicate that the diffuser near-field is only stable for a limited domain of discharge parameters, that is, low densimetric Froude numbers and high submergences. In case of unstable near-field conditions dilutions are determined by frictional effects in the far-field. Furthermore, diffusers with an unstable near-field produce horizontal circulations in the receiving water leading to repeated re-entrainment. These circulations can be controlled by appropriate nozzle orientation.
(*h*) **Buoyant Discharges from Submerged Multiport Diffusers,** D. R. F. Harleman, G. H. Jirka, *Proc. 14th Intl. Conf. Coastal Engrg.*, Copenhagen, Denmark, June 1974.

086-08083-450-44

THE SEA ENVIRONMENT IN MASSACHUSETTS BAY AND ADJACENT WATERS

(*b*) Sea Grant Office, National Oceanic and Atmospheric Administration.
(*c*) Professors J. J. Connor, B. R. Pearce, S. F. Moore, F. M. M. Morel.
(*d*) Field studies and theoretical; basic and applied research.
(*e*) An interdisciplinary study with the objective of a comprehensive understanding of the physical environment of the waters of Massachusetts Bay and adjacent waters. Primary emphasis is on the definition and solution of water quality problems. Initially, work was oriented toward methods and instruments for data acquisition and analysis and for the collection of baseline data throughout the Bay and at specific regions of man's intervention into the coastal zone. Increased surveillance of the Bay environment and development of mathematical models describing the physical environment of Massachusetts Bay is underway.
(*g*) The special instrumentation developments have been completed. An extensive field program including physical and chemical parameter measurements is being conducted in support of modeling efforts for this project. Finite element models for circulation and dispersion in well-mixed shallow water masses have been developed. The essential difficulty is the establishment of suitable numerical stability criteria. Work in this area will continue. Also, the formulation and computer implementation of two-layer models has been initiated and an extensive program of field measurement and computer studies on the Massachusetts Bay is underway.
(*h*) **Determination of Water Quality Parameters in the Massachusetts Bay (1970-1973),** S. L. Frankel, B. R. Pearce, M.I.T., Sea Grant Project Office, *Rept. No. MITSG-74-8*, Nov. 1973 and M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodnamics, *Tech. Rept. No. 174*, Nov. 1973.
Dissolved Nutrient – Seawater Density Correlations and the Circulation in Boston Harbor and Vicinity, J. Karpen, M.I.T., Sea Grant Project Office, *Rept. No. MITSG-74-9, Part II*, Nov. 1973.
Spring Runoff into Massachusetts Bay, 1973, V. Manohar-Maharaj, R. Beardsley, M.I.T., Sea Grant Project Office, *Rept. No. MITSG-74-9, Part I*, Nov. 1973.
Analytical Model for One- and Two-Layer Systems in Rectangular Basins, D. A. Briggs, O. S. Madsen, M.I.T., Sea Grant Project Office, *Rept. No. MITSG-74-4, Part II*, Oct. 1973 and M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 172*, Oct. 1973.
Finite Element Modeling of Two-Dimensional Hydrodynamic Circulation, J. J. Connor, J. D. Wang, M.I.T. Sea Grant Project Office, *Rept. No. MITSG-74-4, Part I*, Oct. 1973 and M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 172*, Oct. 1972.
A Mathematical Model for the Dispersion of Suspended Sediments in Coastal Waters, G. C. Christodoulou, W. F. Leimkuhler, A. T. Ippen, M.I.T., Sea Grant Project Office, *Rept. No. MITSG-74-14*, Jan. 1974 and M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 179*, Jan. 1974.
The Response of Massachusetts Bay to Wind Stress, B. P. Parker, B. R. Pearce, to be published.
Environmental Problems and Monitoring in Coastal Waters, A. T. Ippen, *Invited General Lecture, Proc. 13th Intl. Conf. Coastal Engrg.*, Vancouver, B. C., Canada, July 1972.
Finite Element Model of Two-Layer Coastal Circulation, J. D. Wang, H. J. Connor, 14th Intl. Conf. Coastal Engrg., Copenhagen, June 1974.

086-08084-820-36

ANALYSIS AND PREDICTION OF SUBSURFACE WATER QUALITY

(*c*) Professor J. L. Wilson.
(*d*) Theoretical and experimental; basic research (Master's and Doctoral theses).
(*e*) Several aspects of mass transport in porous media are being explored using mathematical models and laboratory experiments. The emphasis is on phenomena which are of importance in describing and forecasting groundwater quality. Mathematical methods of describing longitudinal dispersion in general nonuniform and unsteady flows are being studied. Also included are mixing phenomena in unsaturated flows and the convective and dispersive mixing process near pumping wells. A general water and mass

balance was developed to apply for basin-wide predictions of groundwater quality.

(*g*) Analytical solutions of the convective dispersion equation for uniform and certain nonuniform, unsteady flows have been obtained using singular perturbation methods. Analytical solutions of the convective dispersion equation for one-dimensional infiltration and multidimensional absorption unsaturated flows have been obtained. A conceptual mathematical "random tube" model of dispersion in unsaturated porous media has been developed. The general basin-wide groundwater quality model has been applied to the long-range forecast and evaluation of the potential groundwater contamination associated with certain land use, waste disposal, and development activities.

(*h*) **Dispersive Mixing in a Partially Saturated Porous Medium,** J. L. Wilson, L. W. Gelhar, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 191*, Sept. 1974.

Ground-Water Quality Modeling, L. W. Gelhar, J. L. Wilson, *Proc. 2nd Natl. Ground Water Quality Symp.*, Denver, Colo., Sept. 1974.

086-08089-870-33

SCREENING MODELS IN STORM WATER MANAGEMENT

(*b*) Office of Water Research and Technology.

(*c*) Professor D. H. Marks.

(*d*) Theoretical; applied research.

(*e*) Mathematical models for the investigation of storm water collection and treatment systems. Optimization techniques are used to find system configurations under several different objectives and policy constraints. The purpose of such models is to screen alternatives for more detailed feasibility and physical simulation studies.

(*h*) **Stormwater Management Model,** P. H. Kirshen, D. H. Marks, *Proc. ASCE, Environ. Eng. Div.* **100,** Aug. 1974.

086-08091-870-36

ANALYSIS MODELS FOR SOLID WASTE COLLECTION

(*b*) Environmental Protection Agency, Office of Solid Waste Management.

(*c*) Professor D. H. Marks.

(*d*) Theoretical; applied research.

(*e*) Mathematical models are developed for common processes in solid waste collection including macroscale problems such as selection of locations and technology for transfer and disposal and microscale problems such as vehicle selection and routing, crew scheduling, districting and collection policy. Use of such models in the decision-making process is stressed. Case studies for the MDC and Brookline are in process.

(*f*) Completed.

(*g*) Development and implementation stage.

(*h*) **Solid Waste Management: Equity Trade-Off Models,** L. Fuertes, J. Hudson, D. H. Marks, *J. Urban Planning and Development Div., ASCE* **100,** 5, Oct. 1974.

Waste Generation Models for Solid Waste Collection, D. Grossman, J. Hudson, D. H. Marks, *J. Environ. Eng. Div., ASCE* **100,** Dec. 1974.

086-08092-800-87

WATER RESOURCE DEVELOPMENT IN ARGENTINA

(*b*) Sub-Secretary of State for Water Resources, Argentina.

(*c*) Professors F. E. Perkins, J. C. Schaake, D. H. Marks, D. C. Major, R. Rodriguez.

(*d*) Theoretical and field investigation; applied research and development.

(*e*) Development of a modern multi-objective planning framework for use in river basin planning in Argentina; training of Argentine professionals in the theory and application of planning methods; demonstration of new planning models as applied to a particular basin planning problem in Argentina.

(*f*) Completed.

(*g*) A series of models for simulation of economic and physical components of typical basins and for screening of proposed alternatives have been developed. These were applied to the particular conditions encountered in the Colorado River Basin. Management and investment alternatives for review by political and technical representatives of the provinces in the basin have been submitted. It remains for the public decision process in Argentina to choose the preferred alternatives. The project also provided training for a group of professionals who have returned to Argentina for implementation and further application of the models which were developed.

(*h*) **A General Purpose Simulation Model for Analysis of Surface Water Allocation Using Large Time Steps,** E. A. McBean, R. L. Lenton, G. J. Vicens, J. C. Schaake, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 160*, Nov. 1972.

A Marginal Analysis – System Simulation Technique to Formulate Improved Water Resources Configurations to Meet Multiple Objectives, E. A. McBean, J. C. Schaake, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 166*, Feb. 1973.

086-08093-390-33

PROJECT EVALUATION: BUDGET CONSTRAINTS

(*b*) Office of Water Research and Technology.

(*c*) Professor D. C. Major.

(*d*) Basic and applied research.

(*e*) The effects of budget constraints on the design of multiobjective water resources projects are evaluated using a mathematical programming model of the Lehigh River, Pa.

(*f*) Completed.

(*g*) Net benefit transformation curves for one, two, and three objectives were obtained, constrained by total and local budgets. The objectives of project design were national income, income distribution, and environmental quality; the purposes of project design included in the model are water supply, power, flood control and recreation.

(*h*) **Project Evaluation in Water Resources: Budget Constraints,** D. C. Major, J. Cohon, E. Frydl, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Res. and Hydrodynamics, *Tech. Rept. No. 188*, Sept. 1974.

086-08719-410-11

DYNAMICS OF COASTAL CURRENTS

(*b*) Coastal Engineering Research Center, U. S. Army Corps of Engineers.

(*c*) Professor C. C. Mei.

(*d*) Theoretical and experimental; basic research (Doctoral thesis).

(*e*) Mean currents induced by waves incident on a long straight beach interrupted by a long jetty or an offshore breakwater. Relation to sand transport by waves.

(*f*) Completed.

(*g*) To provide a semi-empirical theory of nearshore currents due to breaking waves in the presence of a shore-connected breakwater or an offshore breakwater. In particular, the effects of diffraction are studied in addition to refraction by shoaling waters. The concept of radiation stresses recently applied to uniform longshore current and rip currents forms the starting point of the theory. Many empirical relations invoked herein with regard to the surf zone are similar to, and extrapolations of, the ones used in related recent works. Ignoring inertia and lateral turbulent diffusion, the governing equations are solved numerically by the method of finite differences. Sample results for stream functions and mean sea levels are plotted for various beach profiles or incidence angles. For the offshore breakwater the predicted current pattern is consistent with available laboratory observations and the known tendency of tombolo formation. For the shore-connected breakwater, the computed flow pattern exhibits cells in both down-wave and up-wave regions. Directly relevant obser-

vations have not been found but part of the predicted features have indirect experimental support. More experimental and theoretical work is suggested.

(*h*) **Nearshore Currents Due to Breaking Waves,** P. L. F. Liu, C. C. Mei, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 192*, Sept. 1974.

086-08720-470-73

MOORING FORCES AND HARBOR OSCILLATIONS – ATLANTIC GENERATING STATION

(*b*) Public Service Electric and Gas Company, N. J.
(*c*) Professor C. C. Mei (theoretical); Professor O. S. Madsen (experimental).
(*d*) Fundamental and applied research (Doctoral and Master's theses).
(*e*) Wave forces on floating platforms and oscillations in the breakwater enclosure for a floating nuclear power station.
(*g*) Theoretical: Based on linearized shallow water theory a variational formulation is derived which permits the use of a hybrid finite element method to tackle the problem of complex geometry. Analytical solutions are used for the neighborhoods of infinity (sea) or of a singular point (sharp breakwater tip) while discrete finite elements are used around the platform and the harbor. Mean harbor amplification and the total wave forces and moments on the platforms are computed. This method can be adapted to other diffraction problems.
Experimental: To verify the theoretical predictions, a model (1:225 horizontal scale) reproducing as closely as possible the geometry and the boundary conditions assumed in the theoretical model is being tested subject to incident, monochromatic waves in a 25 ft x 40 ft wave basin. The wave motion within the breakwater enclosure is measured and compared with theoretical predictions. Experiments are planned to investigate the influence of the breakwaters being partially reflective rather than fully reflective as assumed in the theoretical model.
(*h*) **Oscillations and Wave Forces in a Man-Made Harbor in the Open Sea,** H. S. Chen, C. C. Mei, *Proc. 10th Naval Hydrodyn. Symp., M.I.T.*, June 1974.
Oscillation and Wave Forces in an Offshore Harbor – An Application of Hybrid Finite Element Method, H. S. Chen, C. C. Mei, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 190*, Oct. 1974.

086-08721-520-54

STUDIES OF SHIP HYDRODYNAMICS IN SHALLOW AND RESTRICTED WATER

(*b*) National Science Foundation.
(*c*) Professor C. C. Mei and Professor J. N. Newman (Ocean Engineering).
(*d*) Basic research (Master's and Doctoral theses).
(*e*) Behavior of ship motion in channels of variable depth or width. Ship to ship interactions in shallow water. Effects on channel banks. Nonlinear effects.

086-08722-410-54

STABILITY OF A SAND BED

(*b*) National Science Foundation.
(*c*) Professor O. S. Madsen.
(*d*) Experimental and theoretical; basic research.
(*e*) A theoretical model backed by experimental evidence indicates the importance of considering the flow induced in a porous sand bed, when studying sand and transport by waves in the surf zone.
(*f*) Completed.
(*g*) A theoretical model, combining concepts of hydrodynamics and soil mechanics, shows that the flows induced in a porous sand bed may momentarily cause a failure of the bed as a near-breaking wave passes. Due to such a failure, caused by the flow within the bed itself, sand grains on the bed-water interface will be unable to resist any additional force, such as the turbulent forces associated with the flow of water above the bed. The magnitude of the horizontal pressure gradient at the bottom is the crucial quantity determining whether or not the above failure will take place and laboratory experiments have shown that this pressure gradient is indeed of sufficient magnitude to activate the above mechanism. Thus, the flow induced in the bed may greatly enhance the rate at which sediment is moved due to the action of breaking waves in the surf zone.
(*h*) **The Stability of a Sand Bed Under the Action of Breaking Waves,** O. S. Madsen, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 182*, Mar. 1974.
The Stability of a Sand Bed Under Breaking Waves, O. S. Madsen, *Proc. 14th Coastal Engrg. Conf., ASCE*, Copenhagen, June 1974.

086-08723-410-75

SAND TRANSPORT BY WAVES

(*b*) Dames and Moore.
(*c*) Professor O. S. Madsen.
(*d*) Theoretical and experimental; basic and applied research (Doctoral thesis).
(*e*) Development of an analytical model for the sand transport associated with the combined action of waves and currents.
(*g*) Shields' criterion for the onset of motion in steady, uniform flow has been shown to apply also for the unsteady, oscillatory flow associated with wave motion. By reanalyzing experimental data for the average rate of sand transport under purely oscillatory flow conditions, an empirical expression for the rate of sediment transport associated with oscillatory flow has been developed. This analytical model of sediment transport in unsteady flow is used in conjunction with the sediment continuity equation to investigate the rate of erosion and/or deposition due to a spatially varying wave and current field.
(*h*) **Initiation of Sediment Movement Under Oscillatory Waves: A Discussion,** O. S. Madsen, W. D. Grant, to appear in *J. Sedimentary Petrology*.

086-08724-430-11

POROUS BREAKWATERS

(*b*) Coastal Engineering Research Center, U. S. Army Corps of Engineers.
(*c*) Professor O. S. Madsen.
(*d*) Theoretical and experimental; applied research (Master's and Engineer's theses).
(*e*) Determination of the reflection and transmission characteristics of porous rubble mound breakwaters.
(*g*) A simple yet accurate analytical approach to the determination of the reflection and transmission of relatively long waves normally incident on a porous rubble mound breakwater. An explicit analytical, totally predictive model for the reflection from and transmission through crib-style breakwaters has been developed. For trapezoidal breakwaters the energy dissipation taking place on the seaward slope is evaluated by a combined theoretical and experimental approach and will be used in conjunction with the results for the reflection and transmission characteristics of a crib-style breakwater to predict the wave reflection from and transmission through trapezoidal, porous breakwaters.
(*h*) **Wave Transmission Through Porous Structures,** O. S. Madsen, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **100**, Aug. 1974, pp. 169-188.

086-08725-870-73

OCEANOGRAPHIC STUDIES AT PILGRIM NUCLEAR POWER STATION AND CAPE COD BAY

(*b*) Boston Edison Company and Sea Grant Office of NOAA.
(*c*) Professors J. J. Connor, B. R. Pearce, K. D. Stolzenbach, and Dr. J. G. Steele.
(*d*) Experimental (field studies) and theoretical (Master's and Doctoral theses).

(e) Mathematical modeling of near and far field convective and dispersive processes in coastal areas. Supplemented by field measurements of physical parameters.

(g) Pre- and post-operational field measurements of the Pilgrim Nuclear Power Station heated discharge have been analyzed and compared with analytical surface jet predictions. A one-layer finite element circulation and pollutant transport model has been applied to generate preliminary calculations of pollutant concentrations in Cape Cod Bay. Development is continuing on one and two layer finite element models of far field processes and on improvements in the near field surface jet model to take into account boundary and transport current effects.

(h) **Oceanographic Studies at Pilgrim Nuclear Power Station to Determine Characteristics of Condenser Water Discharge (Correlation of Field Observations with Theory),** J. R. Pagenkopf, D. R. F. Harleman, A. T. Ippen, B. R. Pearce, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 183*, Jan. 1974.

086-08726-340-75

NUMERICAL PREDICTION OF TIDES AND CURRENTS AT SITE OF ATLANTIC GENERATING STATION CAUSED BY LITTLE EGG INLET AND PASSAGE OF A HURRICANE STORM SYSTEM

(b) Dames and Moore.

(c) Professors B. R. Pearce, O. S. Madsen, J. J. Connor.

(d) Application of numerical models.

(e) Fine scale application of a finite-element hydrodynamic model to the immediate vicinity of the offshore power plant to determine tidal elevations and currents with and without the presence of the plant. Large scale application of a finite difference model to the New Jersey Coastline to determine maximum surge heights due to a probable maximum hurricane.

086-08727-870-73

THERMAL STUDIES – ATLANTIC GENERATING STATION

(b) Public Service Electric and Gas Company, N. J.

(c) Professors D. R. F. Harleman, K. D. Stolzenbach.

(d) Theoretical and experimental (field studies) (Master's and Doctoral tneses); basic and applied research.

(e) Pertinent features of the offshore site are a breakwater enclosure for the floating nuclear units, associated facilities for intake and discharge of condenser cooling water, and natural heat processes at the site. This includes predictions of the near and far field temperature distributions for alternative thermal discharge schemes and for a range of naturally occurring conditions in the receiving water.

(g) Experimental studies have been conducted to determine the interaction of the ocean bottom with heated surface and sub-surface discharges. Objective is to develop analytical or numerical techniques for prediction of the near and far-field temperature distribution in coastal waters. Results of measurements of ocean currents and temperature distribution and dye diffusion observations at the proposed site have been incorporated into a mathematical model of the far-field temperature distribution. Statistical characterization of receiving water states is being developed in conjunction with the application of this model.

(h) **Environmental and Analytical Studies of Condenser Water Discharge for the Atlantic Generating Station,** D. R. F. Harleman, E. E. Adams, G. E. Koester, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 173*, June 1973.

Experimental Study of Submerged Single-Port Thermal Discharges, G. E. Koester, *S.M. Thesis*, M.I.T. Dept. of Civil Engrg., May 1974.

086-08728-400-36

PREDICTIVE MODELS FOR UNSTEADY SALINITY AND TEMPERATURE DISTRIBUTION IN ESTUARIES

(b) Environmental Protection Agency and Environmental Devices Corporation.

(c) Professor D. R. F. Harleman.

(d) Theoretical; basic research (Master's and Doctoral theses).

(e) Development of a finite difference model to predict time dependent longitudinal salinity and temperature distributions in an estuary or reservoir. The model couples the continuity and momentum equations for the tidal motion with the one-dimensional transport equations for salinity and temperature, and the time-dependent boundary conditions of tidal range at the ocean end and variable fresh water inflows at the head of the estuary and tributaries along the estuary.

(g) Recent applications include use of the model to predict ambient temperature distributions in Conowingo Reservoir under time varying meteorological conditions and unsteady flows due to the operation of hydroelectric reservoirs at the upstream and downstream boundaries. Comparisons with field data taken prior to the operation of Peachbottom Nuclear Power Station have been madee. Model is being used for post-operational studies.

(h) **A Predictive Model for Transient Temperature Distributions in Unsteady Flows,** D. R. F. Harleman, D. N. Brocard, T. O. Najarian, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 175*, Nov. 1973.

Hydrodynamics of Tidal Motion; Diffusion and Dispersion Processes; Salinity Intrusion and Dispersion, D. R. F. Harleman, *Proc. NATO Advanced Study Inst. on Estuary Dynamics, Natl.* Civil Engrg. Lab., Lisbon, July 1973.

Longitudinal Dispersion and Unsteady Salinity Intrusion in Estuaries, D. R. F. Harleman, M. L. Thatcher, *La Houille Blanche*, No. 1/2, 1974.

Unsteady Salinity Intrusion in Estuaries: Part I: One-Dimensional, Transient Salinity Intrusion with Varying Freshwater Inflow, Part II: Two-Dimensional Analysis of Time-Averaged Salinity and Velocity Profiles, D. R. F. Harleman, J. S. Fischer, M. L. Thacher, Committee on Tidal Hydraulics, Corps of Engrs., *Tech. Bull. No. 20*, Vicksburg, July 1974.

086-08729-400-36

NUMERICAL MODEL FOR INTERACTING WATER QUALITY PARAMETERS IN ESTUARIES

(b) Environmental Protection Agency.

(c) Professors D. R. F. Harleman, F. M. M. Morel.

(d) Theoretical; basic research (Doctoral thesis).

(e) An estuary consisting of channels and junctions is modeled mathematically by a network of one-dimensional channels. A finite element model is used for solution of the equations of motion and mass transfer with tidal advection and dispersion included for each branch of the network. These equations are solved, subject to interactions among branches and boundary conditions on the network as a whole, to provide time-dependent concentration distributions for non-conservative water quality parameters. Current research is on the development of a predictive model for interacting water quality parameters such as temperature, salinity, and nutrients under transient tidal, fresh water inflow and variable waste loading conditions.

(g) Seven components of the total nitrogen cycle have been included in the model due to their relevance to the study of eutrophic processes in estuarine environments. Of the inorganic forms of nitrogen the model includes NH_4^+-N, NO_2^--N and NO_3^--N. The organic forms of nitrogen are phytoplankton-N, zooplankton-N, particulate organic-N (PON) and dissolved organic-N (DON).

(h) **Water Quality Control in Rivers and Estuaries,** D. R. F. Harleman, *Proc. Conf. on Environmental Problems and Environmental Education*, Tech. Univ. of Berlin and M.I.T., June 1974.

086-08730-340-75

SUBMERGED DIFFUSER IN A TIDAL CHANNEL

(b) Stone and Webster Engrg. Corp. and Maine Yankee Atomic Power Company.

(c) Professor D. R. F. Harleman and Dr. G. H. Jirka.

(d) Experimental and theoretical; applied research.

(e) Design of a submerged multi-port diffuser for cooling water discharge from Maine Yankee Atomic Power Station located in Montsweag Bay, Maine. The discharge geometry is a laterally confined tidal channel. Temperature prediction involves the synthesis of hydraulic scale model results with a mathematical model describing the tidal flushing action and the heat decay of the far-field.
(f) Completed.
(g) An initial study was aimed at defining the effect of the model distortion on the extent of the near-field mixing zone. For various orientations with respect to the current direction, it was found that distortion significantly increased the mixing zone. Subsequently, an undistorted model of the channel geometry was constructed at a scale of 1/100. Different diffuser outlays were simulated under unsteady tidal conditions.
(h) **Experimental Study of a Submerged Multiport Diffuser in a Tidal Bay (Condenser Water Discharge from the Maine Yankee Atomic Power Station),** G. H. Jirka, G. E. Koester, D. R. F. Harleman, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 184*, Apr. 1974.

086-08731-340-73

COOLING WATER DISCHARGE STUDIES

(b) Central Maine Power Company and Companhia Portuguesa de Electricidade.
(c) Professor D. R. F. Harleman and Dr. G. H. Jirka.
(d) Experimental and theoretical; applied research (Master's thesis).
(e) Design and predictive studies for two power stations: (1) W. F. Wyman Station in Casco Bay, Maine. This includes both single-port and multi-port submerged discharges to meet state thermal standards. (2) Setubal Power Plant located on the Rio Sado, Portugal. Design objectives were prevention of recirculation and limitation of induced velocities to avoid disturbance of navigation.
(f) Completed.
(g) Wyman Station: The operation of an undistorted tidal model including the near-field and a portion of the far-field indicated that the tidal advective motion and the avaialble water depth were sufficient in magnitude to provide adequate heat disposal by means of a multiport diffuser. Setubal Station: Both surface discharges and submerged diffusers were investigated in an hydraulic scale model and by theoretical models. Results indicate that the design objective can be met by the use of a surface discharge.
(h) **Experimental Study of the Cooling Water System, Setubal Power Plant, Rio Sado, Portugal,** G. H. Jirka, J. Lee, D. R. F. Harleman, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 185*, Apr. 1974.
Experimental Investigation of Submerged Condenser Cooling Water Discharge into Casco Bay (William F. Wyman Station), S. M. White, G. H. Jirka, D. R. F. Harleman, M.I.T., Dept. of Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 186*, July 1974.

086-08732-870-52

EVALUATION OF WATER TEMPERATURE PREDICTION MODELS

(b) Energy Research and Development Administration.
(c) Professor D. R. F. Harleman, Dr. G. H. Jirka and Dr. G. Abraham.
(d) Theoretical; basic and applied research.
(e) Study to assist the nuclear power plant licensing branch of ERDA in the assessment of environmental impacts of proposed plants. This will consist of a critical review of temperature prediction models, examining approximations, limitations, degree of field verification and utility. Emphasis is on the formulation of quantitative cirteria for model applicability and on the development of a prediction methodology.
(g) The mathematical formulations of various mathematical models have been analysed. Models have been compared to available laboratory and field data.
(h) **Buoyant Jets in Confined Surroundings,** G. H. Jirka, D. R. F. Harleman, *Proc. Conf. on Thermal Pollution Analysis*, Virginia Poly. Inst., Blacksburg, Va., May 1974.

086-08733-050-00

VERTICAL BUOYANT JET INVESTIGATIONS

(b) Laboratory research and M.I.T. Energy Laboratory.
(c) Professor D. R. F. Harleman and Dr. G. H. Jirka.
(d) Theoretical and experimental; basic and applied research (Master's theses).
(e) Two problems were dealt with: (1) The effect of low Reynolds numbers on the turbulent entrainment of vertical buoyant jets. This is important in the design and choice of scales for hydraulic models. (2) The stability and dilution characteristics of buoyant jets in shallow water.
(f) Completed.
(g) (1) Turbulent jet dilution is found to be independent of Reynolds number for non-buoyant jets above a critical Reynolds number of 1500 and for buoyant jets with average densimetric Froude numbers above a critical Reynolds number of about 1200. These results were derived from detailed measurements of jet dilutions in laboratory experiments. (2) An axisymmetric vertical buoyant jet is stable only for a limited range of jet densimetric Froude numbers and submergences. A stability criterion has been derived and verified in laboratory experiments. In case of unstable conditions, a large toroidal eddy persists around the jet resulting in limited dilution. This has been analysed and verified using stratified flow theory.
(h) **Temperature Reduction in a Submerged Vertical Jet in the Laminar Turbulent Transition,** C. D. Ungate, *S.M. Thesis*, M.I.T., Dept. Civil Engrg., Sept. 1974.
The Mechanics of a Vertical Axisymmetric Buoyant Jet in Shallow Water, J. H. W. Lee, *S.M. Thesis*, M.I.T., Dept. Civil Engrg., Aug. 1974.

086-08734-440-75

DYNAMICS OF SHALLOW COOLING PONDS

(b) Stone and Webster Engrg. Corp. and Virginia Electric Power Company.
(c) Professors D. R. F. Harleman, J. J. Connor and Dr. G. H. Jirka.
(d) Experimental and theoretical; basic and applied research (Doctoral thesis).
(e) Basic study of the buoyancy driven vertical circulation of cooling water into long shallow side arms of cooling ponds; development of a transient cooling pond model for heat distribution in shallow cooling ponds with lateral and vertical restrictions. This includes the development of a two-layered finite element model for solution of the mass heat and momentum conservation equations. Specific application of this investigation is the North Anna Cooling Lake in Virginia.
(g) An experimental schematic study of the side arm circulation has been initiated and simplified theoretical models have been developed. A segmented transient cooling pond model has been formulated and predictions for various plant and meteorological conditions have been made.

086-08735-410-00

DIFFUSER INDUCED CIRCULATIONS IN SHALLOW COASTAL ZONES

(b) Waste Heat Management Research Program of the M.I.T. Energy Laboratory.
(c) Professor D. R. F. Harleman, Dr. G. H. Jirka and Dr. J. G. Steele.
(d) Theoretical and experimental; basic and applied research (Doctoral thesis).
(e) Submerged multiport diffusers for the disposal of waste heat from thermal-electric power generating facilities discharge a considerable amount of cooling water with

substantial momentum. In shallow coastal waters these diffusers have the potential of inducing currents of considerable magnitude. An understanding of the induced current pattern is necessary to assess potential heat re-entrainment and the effect on coastal morphology. A theoretical investigation combined with a series of basic experiments is planned.

086-08736-340-73

HEAT DISPOSAL FROM EMERGENCY CORE COOLING

(*b*) Offshore Power Systems.
(*c*) Professor D. R. F. Harleman and Dr. G. H. Jirka.
(*d*) Theoretical and experimental; basic and applied research (Master's thesis).
(*e*) Nuclear power plants release a transient heat load to the environment in case of normal and emergency shutdown procedures. The study is concerned with the external fluid mechanics of this heat disposal into a body of receiving water. The primary objective is an investigation of the cooling characteristics of offshore floating nuclear power plants which release the heat into a breakwater enclosure and are subject to regulatory specifications.

086-08737-870-54

GENERATION EXPANSION MODEL FOR ELECTRICAL ENERGY UNDER ENVIRONMENTAL CONSTRAINTS

(*b*) National Science Foundation.
(*c*) Professor D. H. Marks and Professor F. C. Schweppe (M.I.T. Energy Laboratory).
(*d*) Theoretical; applied research.
(*e*) Optimization models for the investigation of the long-range technology and siting options for electric power subject to environmental constraints.
(*g*) Model development and implementation stage.
(*h*) **Economic Environmental System Planning,** F. C. Schweppe, D. H. Marks, et al., *Proc. IEEE Power Engrg. Soc., 1974 Summer Mtg.*, Inst. Electrical and Electronic Engrg., Anaheim, Calif., July 1974.

086-08738-340-54

POLICY OPTIONS IN REGIONAL POWER PLANT SITING: METHODOLOGY AND A NEW ENGLAND CASE STUDY

(*b*) National Science Foundation.
(*c*) Professor D. H. Marks.
(*d*) Applied research.
(*e*) Methodology and quantitative models for examining the impact on a regional power expansion plan of fuel options (particularly coal) and environmental controls.
(*g*) Model development.

086-08739-820-33

STOCHASTIC MODELING OF GROUNDWATER SYSTEMS

(*b*) Office of Water Research and Technology, U. S. Dept. of the Interior.
(*c*) Professors L. W. Gelhar, J. L. Wilson.
(*d*) Theoretical; applied research.
(*e*) A primary goal of this research is the development of mathematical models of groundwater systems which emphasize the stochastic processes which are inherent in most natural subsurface flow systems. The stochastic models will be based on the deterministic equation of groundwater flow with boundary conditions and input considered to be random functions of time or space. Applications of these stochastic groundwater models will also be developed. Methods of determining aquifer properties and natural recharge will be devised based on the results of the mathematical models.
(*g*) Linear analytical aquifer models have been developed to describe the spectral response characteristics of phreatic aquifers subject to time variable accretion and fluctuations in adjacent stream state. The effects of aquifer slope, flow zone thickening, vertical flow, spatial variability, unsaturated zone storage, etc., are analyzed and conditions under which these factors can be neglected are determined. Nonlinear numerical aquifer simulations predict the overall effects of nonlinearity on the spectral response of phreatic aquifers. Nonlinear effects are typically quite small for field conditions. Aquifer parameters are determined by comparing the observed spectral response of an aquifer with the linear theory.
(*h*) **Stochastic Analysis of Phreatic Aquifer,** L. W. Gelhar, *Water Resour. Res.* **10,** 3, pp. 539-545, June 1974.
Stochastic Modeling of Groundwater Systems, L. W. Gelhar, P. Y. Ko, H. K. Kwai, J. L. Wilson, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 189*, Sept. 1974.

086-08740-220-54

INTERACTION BETWEEN TURBULENT FLOWS AND PERMEABLE BOUNDARIES

(*b*) National Science Foundation.
(*c*) Professor J. L. Wilson.
(*d*) Experimental and theoretical; basic research (Master's and Doctoral theses).
(*e*) The role of turbulence in sediment transport mechanics was investigated through observations of turbulence structure near porous wavy boundaries. Experiments were made in an air flow facility using hot-wire anemometry.
(*f*) Completed.
(*g*) Undular boundary flows were analyzed using a potential flow model for flow outside the boundary and the linear Darcy Law inside the porous media. A series of small-scale flow resistance experiments was made with air flow in pipes with sinusoidally varying granular porous boundaries. Both observed and predicted friction factors increase sharply with Reynolds number. A large facility has been built to obtain detailed measurements of mean flow and turbulence over the porous wavy boundary.
(*h*) **Interaction Between Turbulent Flow and Undular Permeable Boundaries,** R. T. Ho, L. W. Gelhar, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 180*, Feb. 1974.

086-08741-820-88

TRAINING OF SPANISH ENGINEERS IN THE FIELD OF GROUNDWATER POLLUTION

(*b*) Food and Agriculture Organization of the United Nations.
(*c*) Professors J. L. Wilson, R. L. Lenton.
(*d*) Training program; applied research (Master's thesis).
(*e*) A training program for four Spanish engineers and an economist in the field of groundwater pollution has been developed. The program is structured around formal subjects, special seminars, work-study trips, a case study, and a state-of-the-art review. Areas of interest include the causes, types and extent of pollution; methods of analysis – simulation, prediction and optimization; technology of groundwater pollution prevention, monitoring, detection and control; and methods and effects of pollution control – environmental, economic, legal and social.

086-08742-890-00

DISAGGREGATED DEMAND MODELS FOR MUNICIPAL SERVICES

(*b*) Sloan Research Fund.
(*c*) Professor D. H. Marks.
(*d*) Theoretical; applied research.
(*e*) Disaggregated behavioral based demand models using statistical techniques and readily available data are used to predict the demand for municipal services.
(*g*) Model development, case study.

086-08743-870-54

EVALUATION OF POLICY RELATED RESEARCH IN SOLID WASTE MANAGEMENT

(*b*) National Science Foundation – Social Systems.
(*c*) Professor D. H. Marks.
(*d*) Research evaluation.

(*e*) Systematic evaluation of policy related research in solid waste management – major topics are system management, collection, transfer, recycling, processing, storage, treatment and disposal.
(*f*) Completed.
(*g*) Evaluations completed.
(*h*) **Evaluation of Policy Related Research in Solid Waste Management,** J. Hudson, F. Gross, D. Wilson, D. H. Marks, M.I.T., Dept. Civil Engrg., *Rept. No. 74-56*, Oct. 1974.

086-08744-800-33

SCREENING MODELS FOR PLAN FORMULATION

(*b*) Office of Water Research and Technology – Rockefeller Foundation.
(*c*) Professors D. H. Marks, D. C. Major, S. A. West.
(*d*) Theoretical and applied research.
(*e*) Investigations to show the role of analytic models in the regional planning process. Emphasis is on water and related land use planning such as the ongoing project in the 4,400 square mile South East New England Study by the New England River Basin Commission. Objectives of the study are Single resource supply models, such as water supply, water quality management, power plant siting; Land use – water resource impacts modeling; Resource allocation models; and, Evaluation – indices for quality of life, eliciting preferences for alternative development plans.

086-08745-810-00

THEORETICAL FREQUENCY OF WATERSHED YIELD

(*c*) Professor P. S. Eagleson.
(*d*) Theoretical; basic research.
(*e*) Use of rainfall statistics and separate humid-climate and arid-climate models of annual water loss to derive the theoretical distribution of long-term watershed yield.

086-08746-810-30

A CONCEPTUAL MODEL OF CONTINENTAL WATER STORAGE AND FLUX

(*b*) U. S. Geological Survey.
(*c*) Professors P. S. Eagleson, I. Rodriguez.
(*d*) Theoretical; basic research.
(*e*) The framework for a conceptual model designed to achieve a continental and, ultimately, global operational capability in modeling the hydrologic cycle has been built. Research is being conducted on the structure of the model and data collection issues.

086-08747-800-33

ESTIMATION OF HYDROLOGIC AND ENGINEERING PARAMETERS FOR WATER RESOURCES MANAGEMENT

(*b*) Office of Water Research and Technology.
(*c*) Professor I. Rodriguez.
(*d*) Theoretical; applied research.
(*e*) A methodology has been developed for Bayesian estimation of the hydrologic parameters which are used in systems analysis models.
(*f*) Completed.
(*g*) The proposed methods have been implemented and illustrated in the following specific areas: Bayesian estimation of streamflow extreme values; joint use of local and regional information for optimum estimation of hydrologic parameters; extreme value distributions for total value of rainfall; and hydrologic data synthesis which accounts for the uncertainty in the parameters of an autoregressive model.
(*h*) **The Estimation of ρ in the First Order Autoregressive Model: A Bayesian Approach,** R. L. Lenton, I. Rodriguez-Iturbe, J. C. Schaake, Jr., *Water Resour. Res.* **10**, 2, pp. 227-241, Apr. 1974.
On the Collection, the Analysis, and the Synthesis of Spatial Rainfall Data, R. L. Lenton, *Ph.D. Thesis*, M.I.T., Dept. Civil Engrg., Sept. 1974.
On the Transformation of Point Rainfall to Areal Rainfall, I. Rodriguez-Iturbe, J. M. Mejia, *Water Resour. Res.* **10**, 9, p. 729-736, 1974.
Bidimensional Spectral Analysis of Rainfall Events, A. E. Rhenals-Figueredo, *S.M. Thesis*, M.I.T., Dept. Civil Engrg., May 1974.
A Bayesian Approach to Hydrologic Time Series Modeling, G. J. Vicens, I. Rodriguez-Iturbe, J. C. Schaake, Jr., M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 181*, Mar. 1974.
The Methodology of Bayesian Inference and Decision-Making Applied to Extreme Hydrologic Events, E. F. Wood, I. Rodriguez, J. C. Schaake, Jr., M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 178*, Jan. 1974.

086-08748-800-33

SYSTEMATIC APPROACH TO WATER RESOURCES PLAN FORMULATION

(*b*) Office of Water Research and Technology, Dept. of the Interior.
(*c*) Professors J. C. Schaake, Jr., I. Rodriguez.
(*d*) Theoretical; applied research.
(*e*) Methods are sought to approach river basin planning in a systematic manner which integrates the hydrological and economical aspects of the project.
(*f*) Completed.
(*g*) A methodology has been developed to formulate improved system design and operating policies. This methodology utilizes a newly developed procedure for estimating marginal economic benefits in water resources system simulation programs.
(*h*) **Systematic Approach to Water Resources Plan Formulation,** edited by J. C. Schaake, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 187*, July 1974.

086-08749-800-54

BAYESIAN METHODOLOGY FOR WATER RESOURCES RESEARCH

(*b*) National Science Foundation.
(*c*) Professor I. Rodriguez.
(*d*) Theoretical; applied research.
(*e*) Development of Bayesian methodologies for application in hydrologic analysis and water resources planning. The work is being focused in: Bayesian regression analysis; Bayesian approach to multivariate Markov models; and Model Selection in hydrologic problems.
(*h*) **A Statistical View of Parameter Estimation in Multi-Response Hydraulic Systems,** I. Rodriguez-Iturbe, N. C. Matalas, *ASCE Spec. Conf. on Probabilistic Methods in Engrg.*, Stanford Univ., June 1974.

086-08750-810-44

A FRAMEWORK FOR LINKING THE ECONOMICS, PHYSICS AND STATISTICS IN THE DESIGN OF AN OPTIMAL RAINFALL DATA COLLECTION NETWORK

(*b*) National Weather Service, NOAA, U. S. Dept. of Commerce.
(*c*) Professor I. Rodriguez.
(*d*) Theoretical; applied research.
(*e*) Network design schemes which allow consideration of spatial correlation of measured process (prior knowledge); physics describing the measuring system; errors involved in the measuring techniques; errors in the modeling of the area; and joint consideration of statistical and economic properties of the possible designs.

086-08751-810-44

HYDROLOGIC NETWORK DESIGN

(*b*) U. S. Weather Service.

(*c*) Professors P. S. Eagleson, I. Rodriguez.
(*d*) Theoretical; applied research.
(*e*) Analytical study of the accuracy of estimates from a network of point precipitation measuring stations in terms of the variance of the space-process as well as of the time-process.
(*f*) Completed.
(*g*) A methodology for the design of precipitation networks has been formulated. The network problem was discussed in its general conception and then focus has been made on networks to provide background information for the design of more specific gaging systems. The rainfall process is described in terms of its correlation structure in time and space. A general framework was developed to estimate the variance of the sampling long-term mean areal precipitation and mean areal rainfall of a storm event. The variance is expressed as a function of correlation in time, correlation in space, length of operation of the network and geometry of the gaging array. The trade of time vs. space was quantitatively developed and realistic examples were worked out showing the influence of the network design scheme on the variance of the estimated values.
(*h*) **The Design of Rainfall Networks in Time and Space,** I. Rodriguez-Iturbe, J. M. Mejia, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 176*, Nov. 1973.
Multidimensional Characterization of the Rainfall Process, J. M. Mejia, I. Rodriguez-Iturbe, M.I.T., Dept. Civil Engrg., Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, *Tech. Rept. No. 177*, Nov. 1973.
On the Synthesis of Random Fields Sampling from the Spectrum (an Application to the Generation of Hydrological Spatial Processes), J. M. Mejia, I. Rodriguez-Iturbe, *Water Resour. Res.* **10**, 4, 1974.
The Design of Rainfall Networks in Time and Space, I. Rodriguez-Iturbe, J. M. Mejia, *Water Resour. Res.* **10**, 4, 1974.

086-08752-800-56

TECHNOLOGY ADAPTATION: ADAPTING WATER RESOURCES PLANNING METHODS TO LESS DEVELOPED COUNTRIES

(*b*) Agency for International Development, State Department.
(*c*) Professor D. C. Major.
(*d*) Basic and applied research.
(*e*) The process by which water resource planning technology of the U. S. Bureau of Reclamation was transferred to Korean planning agencies is under study. Purpose of the research is to assess the transfer process and to evaluate the potential impact of recent developments in water resource planning methodology.

086-08753-800-33

EXPLORATIONS IN MULTIOBJECTIVE WATER RESOURCE HISTORY

(*b*) Office of Water Research and Technology.
(*c*) Professor D. C. Major.
(*d*) Applied research.
(*e*) Key selected American water resources projects and programs from 1900-1960 are analyzed from the standpoint of multiobjective theory.

086-08754-860-54

MODEL-DATA INTERACTIONS: A RATIONAL BASIS FOR WATER QUALITY MONITORING PROGRAMS

(*b*) National Science Foundation.
(*c*) Professor S. F. Moore.
(*d*) Theoretical and applied research.
(*e*) Develop and apply quantitative methodologies to problems of designing water quality monitoring systems. Uncertainty in models and data of aquatic environments will be treated explicitly using estimation theory and other probabilistic methods of analysis.
(*f*) Completed.
(*g*) Estimation theory techniques are used to develop parameter estimation techniques for a simple water quality model of Boston Harbor. The model results are then used to improve water quality sampling programs.

086-08755-870-53

ATLANTIC/ALASKAN OCS PETROLEUM STUDY

(*b*) Council on Environmental Quality.
(*c*) Professors S. F. Moore, J. W. Devanney (Ocean Engineering), J. B. Lassiter (Ocean Engineering).
(*d*) Applied research.
(*e*) Identification and analysis of environmental effects of hypothetical petroleum discoveries on Atlantic/Alaskan OCS. Study addresses oil spill tracking and weathering, biological effects and environmental implications of drilling/production technologies.
(*f*) Completed.
(*g*) Based on the analysis of hypothetical discharges of oil, it is concluded that certain hypothetical drilling sites in the Baltimore Trough and on Georges Bank are least vulnerable to environmental impacts of oil. Other sites south of Long Island and in the Georgia Embayment pose relatively higher environmental risks due to probability of oil slicks reaching shore within 3-5 days or less. Little is concluded regarding hypothetical drilling sites in the Gulf of Alaska.
(*h*) **Potential Biological Effects of Hypothetical Oil Discharges in the Atlantic Coast and Gulf of Alaska,** S. F. Moore, G. R. Chirlin, B. P. Schrader, C. U. Puccia, M.I.T., Sea Grant Proj. Office, *Rept. No. MITSG-74-19*, Apr. 1974.
Ecological Aspects of Offshore Exploration and Exploitation Activities, S. F. Moore, G. R. Chirlin, B. P. Schrader, C. J. Puccia, presented at *ONS Tech. Conf.*, Stavenger, Norway, Sept. 1974.

086-08756-870-65

LONG ISLAND, NEW YORK, OIL STUDY

(*b*) Nassau-Suffolk Regional Planning Board.
(*c*) Professor S. F. Moore.
(*d*) Applied research.
(*e*) Analysis of potential biological effects of oil spills occurring in nearshore waters of the south coast of Long Island, N. Y.
(*f*) Completed.
(*g*) Nine hypothetical spill scenarios are analyzed, covering a range of oil toxicities and impact zones. Within the uncertainty of the analyses, only slight differences between scenarios can be identified. Impact zones on the open coast may recover slightly faster (3-5 years) than zones in the bays (3-10 years), and "very weathered" oil is expected to have a slightly lesser effect than "weathered" or "unweathered." Based on lower probability of a spill coming ashore on Long Island and longer time to arrive on shore, hypothetical release sites progressively farther south and/or west are preferred to those more north and/or east. Not enough is known about oil transport in the inlets and the bays to predict how much of an oil spill will enter a bay and where the oil will go. Hence, the biological impact, within the bays, of oil spills from hypothetical release sites outside the bays is not estimated.
(*h*) **Potential Biological Effects of Oil Spills Occurring in Nearshore Waters of Long Island's South Coast,** B. P. Schrader, S. F. Moore, B. B. Ackerman, A. D. Long, L. H. Tower. Report to the Nassau-Suffolk Regional Planning Board, June 1974.

086-08757-870-00

DESIGN OF ENVIRONMENTAL MONITORING PROGRAMS

(*b*) Waste Heat Management Group, M.I.T. Energy Laboratory.
(*c*) Professor S. F. Moore.
(*d*) Theoretical; applied research.
(*e*) Development of quantitative methodologies for the design of hydrothermal and biological monitoring programs for waters subject to heated water discharges.

086-08758-870-36

FATE OF TRACE METALS IN SEWAGE OUTFALLS

(*b*) EPA (in part).
(*c*) Professor F. M. M. Morel.
(*d*) Applied research.
(*e*) Chemical modeling of trace metals in sewage and sewage-seawater mixtures. Predictions have been compared to experimental data on the Los Angeles County Outfall System.
(*f*) Completed.
(*g*) The model predicts complete solubilization and mobilization of metals in the farfield. Reduced solids, most notably metallic sulfides, are seen to predominate in the vicinity of the outfall resulting in negligible mobilization of the settled solids. Experimental results are consistent with the prediction of the model.
(*h*) **Fate of Trace Metals in the Los Angeles County Outfall System,** F. M. M. Morel, J. C. Westall, C. R. O'Melia, J. J. J. Morgan, to appear.

086-08759-870-00

A BIOCHEMICAL OR BIOENERGETIC MODEL FOR COASTAL WATERS

(*b*) Doherty Professorship in Ocean Utilization.
(*c*) Professor F. M. M. Morel.
(*d*) Applied research.
(*e*) Develop a biological model of coastal waters for predicting such parameters as nutrient concentrations, biomass or dissolved oxygen. The model will be based on fundamental knowledge of biochemical reactions rather than on a phenomenological approach to plankton dynamics. By using an energetic approach and overlooking some ecological considerations, it is hoped that a true predictive model, without fitting parameters, will be obtained at the price of losing some of the detailed kinetics. The model will be designed for interfacing with current hydrodynamic and chemical models used for water quality studies of coastal waters.

086-08760-870-44

INTERACTIONS BETWEEN TRACE METALS AND PHYTOPLANKTON

(*b*) Sea Grant Office, National Oceanic and Atmospheric Administration.
(*c*) Professor F. M. M. Morel.
(*d*) Fundamental and applied research.
(*e*) In the fundamental part of this project, the interactions between trace metals (particularly copper) and various species of fresh water and marine phytoplankton are being studied systematically. Free copper ion concentration is presumed to be an important factor in inhibiting algal growth and limiting primary productivity. The role that organic ligands, either exuded by the cells or from external sources, play in controlling the biologically availability of trace metals is being explored. This interdisciplinary project is carried on jointly with the Chemistry Department.
A specific application of this fundamental study is to test the hypothesis that certain trace metals normally inhibit the growth of the dinoflagellate *gouyanlax tamarensis* in Massachusetts Bay and that chelation of these metals by organic compounds can reduce the inhibitory effect significantly. Sudden blooms of this dinoflagellate are responsible for the poisonous "red tide" outbreaks in Northern Atlantic waters.
(*g*) Present results include the design and testing of new artificial culture media in which no precipitate forms and trace metals can be precisely controlled. The range of necessary and toxic levels of copper have been determined for the marine diatom *skeletonema costatum*. Gross characterization of copper complexing organics of algal origin has been obtained by electrochemical techniques.

086-08761-890-88

PROFESSIONAL EDUCATION IN ENVIRONMENTAL MANAGEMENT

(*b*) United Nations Environment Program; Clark Foundation.
(*c*) Professor W. H. Matthews.
(*d*) Planning and curricula development.
(*e*) This project will begin answering the following questions in an effort to provide the foundation for creating new educational programs and institutions to meet the critical needs of a wide variety of persons who analyze environmental problems or who make decisions concerning the environment. What does environmental management consist of? What are the various roles which must be performed to comprise effective environmental management? What are the bodies of knowledge that underlie professions in environmental management? Where and in what ways are the various types of environmental managers educated and trained? What new programs and/or institutions are needed to educate environmental managers for responsible positions in all sectors of society?
(*h*) **Conceptual Approach to Professional Education in Environmental Management,** W. H. Matthews, *Earth, Environment and Resources Conf.*, Philadelphia, Pa., Sept. 1974.

086-08762-800-56

A LONG-RANGE PLAN DEFINING ALTERNATIVE STRATEGIES FOR DEVELOPMENT OF THE SAHEL-SUDANO ZONES

(*b*) Agency for International Development, State Department.
(*c*) Professor D. C. Major.
(*d*) Applied research.
(*e*) This project, which is concerned with the allocation of aid resources to the water sector in West Africa, is part of a larger project at M.I.T. concerned with the overall development of the Sahel-Sudan region under the direction of Professor W. W. Seifert.
(*g*) A six-nation region has been divided into water planning areas. A FORTRAN-coded requirements project model and a mathematical programming supply model have been developed to estimate requirements for, and sources and costs of supply of, water in the region. The models have been applied for Mauritania and Senegal.

086-08763-800-87

A LONG-RANGE STUDY OF THE DEVELOPMENT OF SAUDI ARABIA WITH SPECIFIC EMPHASIS ON THE REQUIREMENTS FOR WATER AND ELECTRIC POWER

(*b*) Office of Saline Water Desalination Affairs, Jeddah, Saudi Arabia.
(*c*) Professor R. L. Lenton.
(*d*) Applied research.
(*e*) This study is part of a large project for investigating the long-range requirements for water and electric power in the kingdom of Saudi Arabia, which is being undertaken by the Center for Policy Alternatives under the direction of Professor W. W. Seifert. In this division, work will concentrate on alternative water supply possibilities and their interaction with the total development of the kingdom.

086-08764-880-44

COASTAL ZONE MANAGEMENT

(*b*) National Oceanic and Atmospheric Administration.
(*c*) Professor M. S. Baram.
(*d*) Applied research leading to development of Government program.
(*e*) Development of methods (legal, environmental, etc.) for determining which projects and activities of both the public and private sectors are "in the national interest." Development of criteria for federal evaluation of state coastal zone management programs to ensure that state decision-making provides adequate consideration for "national interest" projects and activities.
(*f*) Completed.
(*g*) Analysis of federal and state roles vis-a-vis the siting of facilities in the coastal zone.

086-08765-880-54

DEVELOPMENT OF LEGAL AND REGULATORY FRAMEWORK FOR MINING OF HARD MINERAL RESOURCES IN THE COASTAL ZONE

(*b*) National Science Foundation.
(*c*) Professor M. S. Baram.
(*d*) Applied research leading to development of policy and regulatory program recommendations.
(*e*) Review and assessment of information on mineral resources in the coastal zone, feasible technologies for extraction, potential impacts and externalities, monitoring capabilities, legal and regulatory authorities and their decision-processes. Analysis and development of appropriate legal and regulatory framework for conduct of coastal mining.
(*h*) **Technology Assessment and the Development of a Legal and Regulatory Framework for Offshore Mining of Hard Minerals,** M. S. Baram, W. Lee, to be published.
Coastal Resource Management: The Case of Offshore Sand and Gravel, M. S. Baram, W. Lee, presented *World Dredging Assoc. Conf., 1974*, to be published.

086-08766-880-80

INTERNATIONAL ENVIRONMENTAL CONTROL: POLLUTION FROM TRACE METALS

(*b*) Ford Foundation and World Health Organization.
(*c*) Professor M. S. Baram.
(*d*) Applied research on physical and social contexts for trace metals pollution, leading to recommendations for social control at national and international levels.
(*e*) Review of information and models of sources and pathways of selected trace metals in the environment and food chain, and their effects on various receptors. Comparative analysis of existing control systems at national level (case studies of Japan, U.S.A. and EEC) and international level (UN, OECD, etc.). Identification of critical points for regulations, incentives, etc., and modeling of proposed systems for social control. Development of program recommendations.
(*f*) Completed.
(*g*) Analyses of national and international efforts to control trace metals pollution, and recommendations for substantive and procedural changes in laws and regulations.
(*h*) **A Systematic Approach to the Control of Pollution by Heavy Metals,** A. S. MacGregor, *S.M. Thesis*, M.I.T., Dept. Civil Engrg., Sept. 1974.

086-08767-340-00

ARTIFICIAL ISLANDS FOR OFFSHORE ENERGY FACILITIES

(*c*) Professor M. S. Baram.
(*d*) Applied research.
(*e*) Review of available information on artificial islands – concepts and developments to-date. Identification of resource and environmental management issues regarding siting of islands; construction of islands; operations of multiple energy facilities thereon; and associated activities. Assessment of adequacy of state and federal policies and regulatory programs.
(*h*) **Artificial Islands for Offshore Energy Facilities,** M. S. Baram, *Testimony at U. S. Federal Energy Administration Hearings*, Aug. 1974.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Meteorology, Cambridge, Mass. 02139. Professor Jule G. Charney, Department Head.

087-08097-480-54

ANALYSIS OF SUBSYNOPTIC-SCALE PRECIPITATION PATTERNS

(*b*) National Science Foundation.
(*c*) Dr. Pauline M. Austin.
(*d*) Experimental, basic research.
(*e*) Observations of storms within 200 km of Cambridge, Mass., are made with quantitative radar and rain gauges which have high resolution in time. Data have been accumulated for a number of years and are being analyzed to provide detailed descriptions and statistics of the small-scale structure in storms.
(*g*) Have taken many radar observations over tropical Atlantic Ocean in connection with GARP Tropical Atlantic Experiment.
(*h*) **A Technique for Computing Vertical Transports by Precipitating Cumuli,** P. M. Austin, R. A. Houze, Jr., *J. Atmos. Sci.* **30**, 6, 1973.
A Climatological Study of Vertical Transports by Cumulus-Scale Convection, R. A. Houze, Jr., *J. Atmos. Sci.* **30**, 6, 1973.
The Structure of Precipitation Systems – A Review, T. W. Harrold, P. M. Austin, *J. Recherches Atmos.* **4,** 1974.
A Statistical Analysis of Drop Size Measurements in New England Rainstorms, D. M. Garrison, *M.S. Thesis*, Dept. of Meteor., 1972.
Characteristics and Development of Mesoscale Precipitation Areas in Extra-Tropical Cyclones, *S.M. Thesis*, Dept. of Meteor., 1972.
A Kinematic Model to Study the Distribution of Precipitation in a Cumulus Updraft, *S.M. Thesis*, Dept. of Meteor., 1973.

UNIVERSITY OF MASSACHUSETTS, School of Engineering, Amherst, Mass. 01002. Dr. K. G. Picha, Dean.

088-06666-430-20

UTILIZATION OF MOBILE BREAKWATER DEVICES TO REDUCE SURFACE MOTIONS OF SUBMERSIBLE VEHICLES FOR DEEP OCEAN ENGINEERING PURPOSES

(*b*) Office of Naval Research.
(*c*) Dr. Charles E. Carver, Jr., Dept. of Civil Engineering.
(*d*) Experimental; applied research.
(*e*) The attenuation characteristics of a pneumatic and hydraulic breakwater used singly as well as in tandem have been investigated in the UMass Fluid Mechanics Laboratory Wind-Generated Wave Facility. Deep water wave spectra upstream and downstream of the breakwaters are measured as well as the power input to both breakwaters. The reduction in mean wave height is used as a measure of wave attenuation. The wind speed is held constant and discharge rates of air and water to the breakwaters are varied. Both devices are submerged to a depth of two feet. The surface current velocities due to the air and water jet action are measured with a midget current meter.
(*f*) Completed.
(*h*) **Attenuation of Wind-Generated Deep Water Waves by Vertical Jet Breakwaters,** J. M. LaCouture, J. M. Colonell, C. E. Carver, Jr., Univ. of Mass. School of Engrg., *Rept. No. UM-72-6*, June 1972.

088-06681-520-20

WIND TUNNEL TESTING OF MARINE VEHICLE COMPONENTS

(*b*) Office of Naval Research.
(*c*) Dr. D. E. Cromack, Dept. of Mechanical and Aerospace Engineering.
(*d*) Basic and applied; theoretical and experimental; M.S. and Ph.D. theses.
(*e*) The pressure field associated with a ducted propeller has been investigated analytically and experimentally in an open jet wind tunnel.
(*f*) Completed.
(*h*) **Calculation of Inlet Flows by Means of a Closed Vorticity Distribution Applied to Ducted Propellers,** R. J. Weetman, D. E. Cromack, *Rept. No. UM-72-11* (AD No. 754-114).

Calculation of Inlet Flows Applied to Ducted Propellers, R. J. Weetman, D. E. Cromack, *AIAA J. Hydronautics* **7**, 4, Oct. 1973, pp. 153-160.

088-06682-540-14

A STUDY OF AIRBORNE TOWED VEHICLE DYNAMICS

(*b*) U.S. Army Research Office, Durham.
(*c*) Drs. C. R. Poli, D. E. Cromack, Dept. of Mechanical and Aerospace Engineering.
(*d*) Basic and applied; theoretical and experimental; Masters and Ph.D. theses.
(*e*) Stability of slung loads.
(*h*) **Dynamics of Slung Bodies Using a Single-Point Suspension System,** C. Poli, D. Cromack, *J. Aircraft* **10**, 2, Feb. 1973, pp. 80-86.
Dynamics of Slung Bodies Utilizing a Rotating Wheel for Stability, E. Micale, C. Poli, *J. Aircraft* **10**, 12, Dec. 1973, pp. 760-763.

088-07816-440-33

ENVIRONMENTAL FACTORS AFFECTING THE MANAGEMENT OF RESERVOIR WATER QUALITY

(*b*) Office of Water Resources Research and Massachusetts Water Resources Research Center.
(*c*) Dr. Joseph M. Colonell, Dept. of Civil Engineering.
(*d*) Field and laboratory evaluation of theoretical techniques for prediction of reservoir dynamics.
(*e*) Overall objective to achieve a thorough comprehension of the physical processes which affect the dynamics of a lake or reservoir. Knowledge of the intimate relationship between water quality and water dynamics can then be employed to evolve useful systems of reservoir management. The initial emphasis of this research is on the evaluation and improvement of available techniques for modeling (mathematically) the hydrodynamic and thermodynamic behavior of a large body of water. A major portion of the work is involved with experimental investigations of the complex response of a reservoir to hydrologic and meteorologic influences. Field measurements are being conducted at Quabbin Reservoir in central Massachusetts.
(*f*) Completed January 1975.
(*h*) **Design and Assembly of an Automatic Hydrologic Data Acquisition System,** P. N. Turbide, J. M. Colonell, F. S. Hill, *WRRC Spec. Rept. No. 44*, Amherst, Mass., 121 pages, June 1974.

088-07817-430-20

SIMULATION TECHNIQUES FOR DYNAMIC MODELING OF OCEAN ENGINEERING STRUCTURES

(*b*) Office of Naval Research.
(*c*) Dr. Joseph M. Colonell, Dept. of Civil Engineering.
(*d*) Experimental; applied research.
(*e*) Models of simple ocean engineering structures are being tested for their response to wind-generated waves in a laboratory sea wave facility designed by the author in conjunction with another project (06666). The objective is to examine basic similitude relationships for fixed and floating structures in a random seaway. Also under investigation are certain aspects of air-sea interaction processes which are pertinent to the establishment of valid similitude relationships.
(*f*) Completed September 1973.
(*h*) **Spectral Development of Wind-Generated Water Waves in a Laboratory Facility,** J. P. Jacobson, J. M. Colonell, *Rept. No. UM-72-9*, 83 pages, Dec. 1972.
Laboratory Experiments to Determine the Structural Response of a Vertical Pile Subjected to Wind-Generated Water Waves in a Laboratory Facility, E. J. Chacko, J. M. Colonell, *Rept. No. UM-73-4*, 121 pages, Mar. 1973.
Spectral Development of Wind-Generated Waves, J. M. Colonell, J. P. Jacobson, *Trans. Amer. Geophys. Union* **54**, 11, p. 119, Nov. 1973.

088-07819-410-00

DYNAMICS OF BEACH AND WAVE INTERACTION

(*c*) Dr. Joseph M. Colonell, Dept. of Civil Engineering.
(*d*) Field, laboratory, and theoretical investigation; applied research.
(*e*) Under investigation are techniques for analysis of beach response to wave action. Methods have been developed for automated display of beach profile measurements in support of the analysis of beach and wave interaction.
(*h*) **Causes of Nonuniform Wave Energy Distribution Over the Shelf and Along the Shoreline,** V. Goldsmith, J. M. Colonell, R. J. Byrne, *Proc. Intl. Symp. on Interrelationships of Estuarine and Continental Shelf Sedimentation*, Bordeaux, July 1973.
Wave Refraction Analysis: Aid to the Interpretation of Coastal Hydraulics, J. M. Colonell, S. Farrell, V. Goldsmith, *Hydraulic Engrg. and the Environment, ASCE*, pp. 131-140, Aug. 1973.
Results of Ocean Wave-Continental Shelf Interaction, V. Goldsmith, J. M. Colonell, *Proc. 14th Intl. Conf. Coastal Engrg.*, Copenhagen, June 1974.

088-08772-030-20

ANALYTICAL AND EXPERIMENTAL STUDIES ON THE DETERMINATION OF ADDED MASS COEFFICIENTS FOR DEEP SUBMERGENCE VEHICLES

(*b*) Office of Naval Research.
(*c*) Dr. Joseph M. Colonell, Dept. of Civil Engineering.
(*d*) Experimental and theoretical; applied research.
(*e*) Develop more reliable numerical and experimental methods for prediction of added mass effects for practical design analysis of DSV maneuvering problems.
(*f*) Discontinued April, 1974.
(*h*) **Experimental Determination of Hydrodynamic Mass Effects,** A. J. Ciesluk, J. M. Colonell, *Rept. No. UM-74-1*, 67 pages, Apr. 1974.

088-08773-620-70

STUDY OF COATING (LUBRICATION) FLOWS

(*b*) Kendall Corp., P. J. Schweitzer Company, Eastman Kodak.
(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.
(*d*) Experimental and theoretical, basic and applied, Ph.D. and M.S. theses.
(*e*) Theoretical and experimental studies of lubrication type flows, with special application to the dynamics of coating of thin liquid layers onto moving surfaces, is underway. Of particular interest is the role of viscoelasticity in these flows, and the development of appropriate theoretical analyses for viscoelastic fluids.
(*g*) To date an analytical method based on perturbation theory has been carried out, which indicates the direction of viscoelastic effects.
(*h*) **Blade Coating of a Viscoelastic Fluid,** Y. Greener, S. Middleman, *Polymer Engrg. and Sci.* **14**, pp. 791-796, 1974.

088-08774-120-00

MODELING OF POLYMER FLOW PROCESSES

(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.
(*d*) Experimental and theoretical; basic and applied; M.S. and Ph.D. theses.
(*e*) Computational methods are being developed for analysis of flows of complex (non-Newtonian viscoelastic) fluids in complicated flow fields. Experiments are performed in support of the theoretical work.
(*h*) **Laminar Mixing of a Pair of Fluids in a Rectangular Cavity,** D. Bigg, S. Middleman, *I and EC Fund.* **13**, pp. 66-71, 1974.
Mixing in a Screw Extruder. A Model for Residence Time Distribution and Strain, *I and EC Fund.* **13**, pp. 66-71, 1974.

088-08775-250-00

TURBULENT DISPERSION IN DRAG-REDUCING FLUIDS

(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.
(*d*) Experimental; basic; Ph.D.
(*e*) Turbulent pipe flow was examined by measuring the radial dispersion of dyed fluid introduced as an axial point source within the flow. From the classical theory of G. I. Taylor it was possible to calculate parameters that characterize the structure of the turbulent flow field. A comparison was made between water and aqueous solutions of polyethylene oxide (Polyox) at concentrations up to 50 ppm.
(*f*) Suspended.
(*g*) Polyox affects turbulence in the following ways: intensity is reduced; the energy spectrum is shifted toward low frequency; dispersion occurs largely through large scale motion, and intermittency is increased.
(*h*) **Turbulent Dispersion in Drag-Reducing Fluids,** A. R. Taylor, S. Middleman, *J. AIChE* **20**, pp. 454-461, 1974.

088-08776-120-54

GROWTH AND COLLAPSE OF BUBBLES IN VISCOELASTIC FLUIDS

(*b*) National Science Foundation.
(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.
(*d*) Experimental and theoretical; basic research, Ph.D.
(*e*) The dynamics and kinematics of bubble growth or collapse are being studied as a means of measuring the elongational viscosity of viscoelastic fluids.
(*g*) Elongational viscosity in polymeric solutions is observed to decrease with increasing strain rate.
(*h*) **Comments on a New Method for Determination of Surface Tension of Viscous Liquids,** G. Pearson, S. Middleman, *Chem. Engrg. Sci.* **29**, pp. 1051-1053, 1974.

UNIVERSITY OF MIAMI, Department of Mechanical Engineering, School of Engineering and Environmental Design, P. O. Box 248294, Coral Gables, Fla. 33124.

089-09023-870-50

REMOTE SENSING APPLIED TO NUMERICAL MODELING OF THERMAL POLLUTION

(*b*) NASA Kennedy Space Center.
(*c*) T. Nejat Veziroglu, Ph.D., Samuel S. Lee, Ph.D.
(*d*) Theoretical, experimental and field investigations; applied research and development.
(*e*) A generalized three-dimensional, predictive, numerical model is being developed for the prediction of temperature distribution in a large water body receiving hot discharges from power plants' cooling systems. The model takes into account the effects of wind, tide, current and salinity distributions. Remote sensors from aircraft and satellite and in-situ measuring systems are used to provide sea surface temperature, vertical water temperature profile, current and other related data needed for the model development. This model may be applied to power plant sites in coastal regions as well as in lakes.
(*g*) A rigid-lid far-field wind driven circulation model has been completed. Tidal effects and temperature distributions are now being added to the model. A rigid-lid near-field model is being developed. Also included in this project are the free surface far-field and near-field models which are in their early stages of development.
(*h*) **Application of Remote Sensing for Prediction and Detection of Thermal Pollution,** *NASA CR-139182*.
Remote Sensing Applied to Numerical Modeling, *Proc. Remote Sensing Applied to Energy-Related Problems Symp.* Miami, Dec. 1974.

MICHIGAN STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, East Lansing, Mich. 48824. Dr. William C. Taylor, Chairman.

091-08777-210-54

THE EFFECT OF RELEASED GASES ON HYDRAULIC TRANSIENTS

(*b*) National Science Foundation.
(*c*) D. C. Wiggert, Asst. Professor.
(*d*) Experimental and applied numerical research.
(*e*) Investigation of the hydraulic transient response with gas being released from liquid in a long pipeline. Includes an experimental study involving sudden valve closures and resonating conditions with gaseous cavitation in a single pipe, and numerical modeling of two-phase transient pipe flow as gas is being released.
(*f*) Due for completion June 1976.
(*g*) Experimental work underway.

091-08778-820-33

ANALYSIS OF GROUNDWATER FLOW IN RELATION TO WATER QUALITY IMPROVEMENT

(*b*) Office of Water Resources Technology.
(*c*) D. C. Wiggert, Asst. Professor.
(*d*) Applied numerical research.
(*e*) A regional two-dimensional flow analysis of an aquifer is formulated using finite-element techniques. A general algorithm is developed to handle a variety of regional situations including steady or unsteady and confined or unconfined flow.
(*f*) Completed.
(*h*) **Two-Dimensional Finite Element Modeling of Transient Flow in Regional Aquifer Systems,** D. C. Wiggert, *TR-41*, Inst. of Water Research, Mich. State Univ., 102 pages, Aug. 1974.

MICHIGAN STATE UNIVERSITY, College of Engineering, Department of Mechanical Engineering, East Lansing, Mich. 48823. Professor R. W. Little, Department Chairman.

092-08989-160-50

OBLIQUE JET IMPINGEMENT FLOW

(*b*) NASA Langley Research Center.
(*c*) J. F. Foss.
(*d*) Experimental, basic.
(*e*) The far field acoustic noise from the impinging jet flow is considered as a function of the vorticity structure in the impact region of the flow. A digital electronics circuit to process four hot-wire signals from which two velocity components and the transverse vorticity can be extracted is under development. Mean flow measurements for 45 degree and more shallow impingment angles have been acquired.

092-08990-020-22

THE INFLUENCE OF MOLECULAR DIFFUSIVITY IN TURBULENT MIXING

(*b*) Project SQUID.
(*c*) J. F. Foss.
(*d*) Experimental; basic; Ph.D. thesis.
(*e*) Species concentration measurements for both diffusive and non-diffusive gases inside a closed mixing chamber will be made by light scattering techniques; the comparison of these results will reveal the influence of molecular diffusivity for uniform and non-uniform distributions of the fluid densities and turbulence field.

092-08991-010-50

THE INFLUENCE OF THE STATE OF THE BOUNDARY LAYER AT THE INITIATION OF A FREE SHEAR LAYER

(*b*) NASA Langley Research Center.
(*c*) J. F. Foss.
(*d*) Experimental, basic.
(*e*) The data reported in the literature suggests that the asymptotic spread rate parameter of a free shear layer is a function of the boundary layer state at its initiation. A special facility was constructed to evaluate this phenomenon as well as the structural characteristics of the two shear layers.

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UNIVERSITY OF MICHIGAN, College of Engineering, Department of Aerospace Engineering, Ann Arbor, Mich. 48104. Professor R. M. Howe, Department Chairman.

093-07442-010-20

AN INVESTIGATION OF WALL PRESSURE FLUCTUATIONS AND STRUCTURE OF A TURBULENT BOUNDARY LAYER

(*b*) Office of Naval Research and National Science Foundation.
(*c*) Professor William W. Willmarth.
(*d*) Experimental, basic research, Doctoral thesis.
(*e*) Fluctuating velocity and pressure measurements in and beneath turbulent boundary layers on cylinders. Purpose is basic research on turbulence.
(*g*) Study of mean velocity profiles, wall shear stress and wall pressures beneath boundary layers on cylinders aligned with the flow in order to reveal the effect of transverse curvature. Measurements have also been made of the structure of the Reynolds stress in the boundary layer on a flat plate. New information which may lead to a better understanding of the occurrence of bursts and the interaction between the flow in the wall region and the outer region has been revealed.
(*h*) **Structure of the Reynolds Stress Near the Wall,** W. W. Willmarth, S. S. Lu, *J. Fluid Mech.* **55,** 1, p. 65, 1972.
Measurements of the Structure of the Reynolds Stress in a Turbulent Boundary Layer, S. S. Lu, W. W. Willmarth, *J. Fluid Mech.* **60,** 3, p. 481, 1973.
Measurement of the Mean Period Between Bursts, S. S. Lu, W. W. Willmarth, *Phys. of Fluids* **16,** 11, p. 2012, 1973.
Pressure Fluctuations Beneath Turbulent Boundary Layers, W. W. Willmarth, to be published in *Ann. Review of Fluid Mechs.* **7,** 1975.

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UNIVERSITY OF MICHIGAN, College of Engineering, Department of Applied Mechanics and Engineering Science, Ann Arbor, Mich. 48104. I. K. McIvor, Department Chairman.

094-07447-060-54

INTERNAL WAVES. STABILITY OF UNSTEADY FLOWS

(*b*) National Science Foundation.
(*c*) Professor C.-S. Yih.
(*d*) Basic research, mainly theoretical. Doctoral dissertations also supported.
(*h*) **Instability of Stratified Flows as a Result of Resonance,** *Phys. Fluids* **17,** pp. 1483-88, 1974.
Progressive Waves of Permanent Form in Continuously Stratified Fluids, *Phys. Fluids* **17,** pp. 1489-95, 1974.
In addition, dissertations on the stability of unsteady flows have been completed or are in progress.

094-08604-060-20

STRATIFIED FLOWS

(*b*) Office of Naval Research.
(*c*) Professor C.-S. Yih.
(*d*) Basic research, mainly theoretical.
(*e*) All aspects of stratified flows.
(*h*) See 094-07447-060-54. Other papers are in press.

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UNIVERSITY OF MICHIGAN, College of Engineering, Department of Civil Engineering, Ann Arbor, Mich. 48104. Dr. E. F. Brater, Professor of Hydraulic Engineering.

095-05916-810-60

RAINFALL-RUNOFF RELATIONS ON URBAN AND RURAL AREAS

(*b*) U. S. Environmental Protection Agency.
(*d*) Basic research based on analysis of data.
(*e*) Rainfall and runoff data from small watersheds in various stages of urbanization were studied to determine the effect of population density and the characteristics of the basins on storm runoff.
(*f*) Completed.
(*g*) Methods were developed for estimating peak runoff of various frequencies for any degree of urbanization.
(*h*) **Seasonal Effects on Flood Synthesis,** E. F. Brater, S. Sangal, J. D. Sherrill, *Water Resour. Res.* **10,** 3, p. 441, June 1974.
Rainfall-Runoff Relations on Urban and Rural Areas, E. F. Brater, J. D. Sherrill, *Rept. to Office of Research and Monitoring, U. S. Environmental Protection Agency,* Nov. 1974.

095-06424-420-54

WAVE FORCES ON SUBMERGED STRUCTURES

(*b*) National Science Foundation.
(*d*) Experimental; basic research and application to engineering design.
(*e*) Study of forces on submerged pipe lines.
(*f*) Research completed and results published.
(*g*) Coefficients of drag and virtual mass were determined for pipes of various sizes and positions for various wave heights and wave lengths.
(*h*) **Wave Forces on Submerged Pipelines,** E. F. Brater, R. Wallace, *Proc. 13th Coastal Engrg. Conf., ASCE* **III,** p. 1703, 1972.

095-06425-210-54

TRANSIENTS IN GAS DISTRIBUTION SYSTEMS

(*b*) National Science Foundation.
(*c*) Professor V. L. Streeter, E. B. Wylie.
(*e*) Application of characteristics method for analysis of gas distribution systems.
(*f*) Completed.
(*h*) **Unsteady Natural Gas Calculations in Complex Piping Systems,** E. B. Wylie, V. L. Streeter, M. A. Stoner, *Soc. Petroleum Engrs. J.* **14,** 1, Feb. 1974.

095-08200-350-54

EARTHQUAKE INDUCED TRANSIENT PORE PRESSURES IN EARTH DAMS

(*b*) National Science Foundation.
(*c*) Professor V. L. Streeter, E. B. Wylie.
(*d*) Theoretical; applied research.
(*e*) Study of decay of transient pore pressures in earth dams due to sloshing of the reservoir.
(*f*) Completed.
(*h*) **Soil Motion Computations by Characteristics Method,** V. L. Streeter, E. B. Wylie, F. E. Richart, Jr., *ASCE J. Geotech. Eng.* **100,** GT3, Mar. 1974.

095-08850-410-60

A STUDY OF SHORE PROTECTION PROCEDURES

(*b*) Michigan Department of Natural Resources and NOAA Sea Grant Program.
(*d*) Laboratory and field investigation.

(*e*) The effectiveness and durability of various shore protection procedures are being investigated.
(*g*) A satisfactory procedure for modeling bluff recession has been developed.
(*h*) Interior reports have been presented to the sponsors.

095-08851-070-54

NONLINEAR SATURATED SOIL MOTIONS RESULTING FROM EARTHQUAKES

(*b*) National Science Foundation.
(*c*) Professor V. L. Streeter, E. B. Wylie.
(*d*) Theoretical; applied research.
(*e*) Study of liquefaction of soils during seismic activity.
(*h*) **Seismic Response of Reservoir-Dam Systems,** E. B. Wylie, *ASCE, J. Hydraulics Div.*, HY3-6, Mar. 1975.
Bedrock Motions Computed from Surface Seismograms, C. N. Papadakis, V. L. Streeter, E. B. Wylie, *ASCE, J. Geotechnical Eng. Div.* **100,** GT10, Oct. 1974.

095-08852-350-13

DYNAMIC ANALYSIS OF LOPEZ DAM

(*b*) Corps of Engineers, Waterways Experiment Station, Vicksburg.
(*c*) Professor E. B. Wylie.
(*d*) Applied research.
(*e*) Two-dimensional dynamic analysis of an earth-fill dam.
(*f*) Completed.
(*h*) **Transient Two-Dimensional Analysis of Soils by Lattice-Work Method; Lopez Dam Case Study,** E. B. Wylie, V. L. Streeter, C. N. Papadakis, F. E. Richart, Jr., *Rept. UMEE-74R3*, p. 111, Dept. Civil Engrg., Univ. of Mich., Oct. 1974.

095-08853-210-54

TRANSIENT FLOW THROUGH OPEN AND CLOSED CONDUITS

(*b*) National Science Foundation.
(*c*) Professor V. L. Streeter, E. B. Wylie.
(*d*) Completed.
(*e*) Study of unsteady liquid flow in pipes and open channels.
(*h*) **Transient Analysis of Offshore Loading Systems,** V. L. Streeter, E. B. Wylie, *ASME, Paper No. 74-Pet-2, Petroleum Eng. Conf.*, Dallas, Tex., Sept. 1974.
Waterhammer and Surge Control, V. L. Streeter, E. B. Wylie, *Ann. Rev. Fluid Mech.* **6,** pp. 57-74, 1974.

095-08854-820-00

TRANSIENT FLOW IN AQUIFERS

(*c*) Professor E. B. Wylie.
(*d*) Theoretical; development.
(*e*) Numerical analysis of unsteady groundwater flow.

UNIVERSITY OF MICHIGAN, Cavitation and Multiphase Flow Laboratory, Department of Mechanical Engineering, Ann Arbor, Mich. 48105. Frederick G. Hammitt, Professor-in-Charge (reports on all projects available by writing to laboratory).

096-06147-230-54

BUBBLE NUCLEATION, GROWTH AND COLLAPSE PHENOMENA

(*b*) National Science Foundation.
(*d*) Theoretical and experimental; basic research for various Ph.D. theses.
(*e*) Study of the details of inception, growth and collapse of vapor and gas bubbles in liquids. This has included the development of methods for measuring entrained gas microbubble spectra in water and correlating with cavitation nucleation pressure thresholds. Effects of fast neutron irradiation and strong magnetic fields have been included along with variation of temperature, pressure, settling-time, total gas content, etc. Electrical conductivity and optical properties of liquids have been used for instrumentation development. It is expected that this work can be carried on into sodium and other liquids, but so far has been mostly limited to water.

096-08123-230-70

CAVITATION AND DROPLET IMPACT EROSION TESTING (Various Small Projects)

(*b*) Birdsboro Corporation, B. F. Goodrich, Westinghouse Electric, General Electric, Chandler Evans, International Nickel, French Atomic Energy Commission, Naval Air Development Center, Alcoa Foundation.
(*d*) Experimental and theoretical, several Ph.D. theses.
(*e*) Determination of the relative resistances of metals and alloys to cavitation and impact erosion under different conditions of temperature and pressure, including sodium. Vibratory facility used for cavitation damage tests, but repeating water gun and rotating arm for droplet impact studies. Theoretical work involves numerical studies of details of droplet impact on materials both from fluid-flow and material viewpoints.

096-08779-130-54

WET STEAM FLOWS

(*b*) National Science Foundation.
(*d*) Experimental and theoretical, Ph.D. theses possible.
(*e*) Experimental and theoretical investigation of low pressure wet steam flows (pertinent to low pressure end of large steam turbines) across blading profiles. Includes measurement of liquid film thicknesses on profiles, and downstream droplet size, velocity and population distributions, as well as theoretical studies of liquid film stability under high-velocity steam flows. Downstream liquid particle size and velocity distributions can be used as input for our droplet impact erosion work described in the previous project description.

UNIVERSITY OF MICHIGAN — DEARBORN, Division of Engineering, Fluid Mechanics Laboratory, Dearborn, Mich. 48128. Professor T. Y. Na, Laboratory Director.

097-08857-630-00

APPLICATIONS OF JET PUMPS IN INTERNAL COMBUSTION ENGINES

(*d*) Experimental applied research.
(*e*) Feasibility study of the application of jet pumps to replace part of the pumping duties in the internal combustion engine.
(*f*) Completed.
(*g*) It was concluded that the idea is feasible for racing engines and for passenger cars operating under certain conditions.
(*h*) **An Experimental Feasibility Study of Applying Jet Pumps As Scavenge Pump in I C Engines,** *Proc. 2nd Mtg. on Jet Pumps and Ejectors*, British Hydromech. Res. Assoc., Cambridge, England, Mar. 26-28, 1975.

097-08858-020-00

TURBULENT CHANNEL FLOWS

(*d*) Theoretical basic study.
(*e*) Theoretical study of turbulent channel flow problems by introducing new mixing length model and mathematical methods.
(*h*) **Turbulent Flow Development Characteristics in Channel Inlets,** *Appl. Sci. Res.*, 1973.
Prediction of Heat Transfer in Turbulent Pipe Flow With Constant Wall Temperature, *J. Heat Transfer* **96,** pp. 253-254, May 1974.

UNIVERSITY OF MINNESOTA, Department of Aerospace Engineering and Mechanics, Minneapolis, Minn. 55455. Professor P. R. Sethna, Department Head.

098-07488-000-54

HYDRODYNAMIC STABILITY

(*b*) National Science Foundation.
(*c*) Professor Daniel D. Joseph.
(*d*) Theoretical; basic research; M.S., Ph.D. theses.
(*e*) Theoretical research on the stability of a broad class of fluid motions.
(*g*) The implications of energy analysis for the stability of classical motions (Couette and Poiseuille flows in annuli, pipes, channels, etc., and variations on the Benard problem) are emphasized. A global theory of stability is sought in which linear theory, energy theory and the theory of branching solutions of the Navier-Stokes equations play unique and complementary roles. Also developed are aspects of near-linear perturbation theories.
(*h*) **Nonlinear Diffusion Induced by Nonlinear Sources,** D. D. Joseph, E. M. Sparrow, *Quart. Appl. Math.* **XXVIII,** pp. 327-342, Oct. 1970.
Stability of Convection in Containers of Arbitrary Shape, D. D. Joseph, *J. Fluid Mech.* **47,** pp. 257-282, 1971.
Quasilinear Dirichlet Problems Driven by Positive Nonlinear Sources, D. D. Joseph, T. S. Lundgren, *Arch. Rat. Mech. Anal.* **46,** pp. 241-269, 1973.
Contributions to the Nonlinear Theory of Stability of Viscous Flow in Pipes and Between Rotating Cylinders, D. D. Joseph, W. Hung, *Arch. Rat. Mech. Anal.* **44,** pp. 1-22, 1971.
Global Stability of Spiral Flow, Part II, D. D. Joseph, W. Hung, B. Munson, *J. Fluid Mech.* **51, pp. 593-612, 1972.**
Viscous Incompressible Flow Between Concentric Rotating Spheres: Part I, Basic Flow, D. D. Joseph, B. Munson, *J. Fluid Mech.* **49,** pp. 289-303, 1971.
Viscous Incompressible Flow Between Concentric Rotating Spheres: Part II, Hydrodynamic Stahility, D. D. Joseph, B. Munson, *J. Fluid Mech.* **49,** pp. 305-318, 1971.
Heat Transport in a Porous Layer, F. H. Busse, D. D. Joseph, *J. Fluid Mech.* **54,** 3, pp. 521-543, 1972.
Bifurcating Time Periodic Solutions and Their Stability, D. D. Joseph, D. Sattinger, *Arch. Rat. Mech. Anal.* **45,** pp. 79-109, 1972.
Subcritical Bifurcation of Plane Poiseuille Flow, D. D. Joseph, T. S. Chen, *J. Fluid Mech.* **58,** p. 337, Apr. 1973.
Remarks About Bifurcation and Stability of Quasi-Periodic Solutions Which Bifurcate from Periodic Solutions of the Navier-Stokes Equations, in *Nonlinear Problems in Physical Science and Engineering*, Springer Lecture Notes in Mathematics (Ed. Stakgold, Joseph and Sattinger), 1973.
Heat Transport in a Porous Layer, D. D. Joseph, V. Gupta, *J. Fluid Mech.* **57,** p. 521, 1973.
Energy Theory of Hydromagnetic Flow, D. D. Joseph, *Proc. Conf. on Mathematical Topics in Stability Theory*, Washington State Univ., 1972.
Domain Perturbations: The Higher Order Theory of Infinitesimal Water Waves, *Arch. Rational Mech. Anal.* **51,** p. 295, 1973.
Friction Factors in the Theory of Bifurcating Poiseuille Flow Through Annular Ducts, D. D. Joseph, T. S. Chen, *J. Fluid Mech.* **65,** p. 189., 1974.
Response Curves for Plane Poiseuille Flow, D. D. Joseph, in *Advances in Applied Mechanics* **XIV,** (Ed.: C. S. Yih), Academic Press, New York, 1974.
Repeated Supercritical Branching of Solutions Arising in the Variational Theory of Turbulence, *Arch. Rational Mech. Anal.* **53,** p. 101, 1974.

098-07489-020-54

THEORETICAL RESEARCH ON TURBULENCE

(*b*) National Science Foundation.
(*c*) Professor T. S. Lundgren.
(*d*) Theoretical basic research; M.S., Ph.D. theses.
(*e*) Appropriate systems of equations and closure hypotheses are being sought which will provide a physical space theory of turbulence.
(*g*) The formulation of the isotropic homogeneous turbulence problem proposed in Lundgren (1971) is being applied to the complete inertial and viscous ranges using successive approximations techniques. Problems in non-isotropic or non-homogeneous turbulence are also under investigation.
(*h*) **A Closure Hypothesis for the Hierarchy of Equations for Turbulent Probability Distribution Functions,** *Proc. Symp. on Statistical Models and Turbulence*, Univ. Calif., San Diego, July 1971.

098-07490-210-54

COUPLED FLOWS IN DUCTS AND POROUS MEDIA

(*b*) National Science Foundation.
(*c*) Professor Gordon S. Beavers.
(*d*) Theoretical and experimental; basic and applied research; M.S., Ph.D. theses.
(*e*) Analytical and experimental research is being performed on a broad class of problems involving flows through and around permeable materials. The experiments include both liquid and gas flows through permeable materials. Flows in channels with non-permeable walls are also under investigation.
(*g*) The following projects are active: (1) Investigation of the slip velocity at a porous wall. (2) Non-Darcy flows through porous materials and packed beds of particles. (3) Laminar-turbulent transition in ducts with permeable and impermeable walls. (4) Compressible flows in permeable materials. (5) The effects of slip velocity on a variety of flow configurations.
(*h*) **Incompressible Turbulent Flow in a Permeable-Walled Duct,** G. S. Beavers, E. M. Sparrow, V. K. Jonsson, R. G. Owen, *J. Basic Engrg., Trans. ASME* **94,** Series D, 2, pp. 314-320, June 1972.
Effect of Velocity Slip on Porous-Walled Squeeze Films, G. S. Beavers, E. M. Sparrow, I. T. Hwang, *J. Lubrication Tech., Trans. ASME* **94,** Series F, 3, pp. 260-265, July 1972.
The Reflection of Weak Shock Waves from Permeable Materials, G. S. Beavers, R. K. Matta, *AIAA J.* **10,** 7, pp. 959-961, July 1972.
Breakdown of the Laminar Flow Regime in Permeable-Walled Ducts, G. S. Beavers, E. M. Sparrow, T. S. Chen, J. R. Lloyd, *J. Appl. Mech., Trans. ASME* **40,** Series E, 2, pp. 337-342, June 1973.
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Laminar Flow in a Rectangular Duct Bounded by a Porous Wall, G. D. Beavers, E. M. Sparrow, B. A. Masha, *Phys. Fluids* **17,** 7, pp. 1465-1467, July 1974.
Boundary Condition at a Porous Surface Which Bounds a Fluid Flow, G. S. Beavers, E. M. Sparrow, B. A. Masha, *AIChE J.* **20,** 3, pp. 596-598, May 1974.

098-08859-120-00

STUDIES IN THE VISCOMETRY OF SLOW MOTIONS OF RHEOLOGICALLY COMPLEX LIQUIDS

(*c*) Professors D. D. Joseph, G. S. Beavers.
(*d*) Theoretical and experimental; basic and applied research; M.S., Ph.D. theses.
(*e*) Experimental and mathematical studies of the mechanics of flow of rheologically complex liquids are being carried out. The immediate aim is to enrich the science and technology of viscometry by developing sets of standard experiments, founded on sound mathematical analysis,

which will lead to reliable viscometric data characterizing the slow motion of rheologically complex fluids. There is also interest in certain mathematical studies of the mechanical foundations of rheology and in the evolution of new methods of analysis.

(*g*) The following projects are active: (1) The rotating rod viscometer. (2) The Tilted Trough Viscometer. (3) Hele-Shaw flows. (4) Free surface viscometers driven by thermal convection. (5) Torsion flow viscometry.

(*h*) **The Free Surface on a Liquid Between Cylinders Rotating at Different Speeds – Part I,** D. D. Joseph, R. Fosdick, *Arch. Rat. Mech. Anal.* **49**, pp. 321-380, 1973.
The Free Surface on a Liquid Between Cylinders Rotating at Different Speeds – Part II, D. D. Joseph, G. S. Beavers, R. Fosdick, *Arch. Rational Mech. Anal.* **49**, pp. 381-401, 1973.
Tall Taylor Cells in Polyacrylamide Solutions, G. S. Beavers, D. D. Joseph, *Physics of Fluids* **17**, p. 650, 1974.
Slow Motion and Viscometric Motion; Stability and Bifurcation of the Rest State of a Simple Fluid, D. D. Joseph, to be published in the *Arch. Rational Mech. Anal.*, 1975.
The Free Surface on a Liquid Filling a Trench Heated From its Side, D. D. Joseph, L. Sturges, to be published in *J. Fluid Mech.*, 1975.
The Rotating Rod Viscometer, G. S. Beavers, D. D. Joseph, to be published in *J. of Fluid Mech.*, 1975.

098-08860-000-70

ROTATING FLOWS

(*b*) Union Carbide Corporation, Nuclear Division.
(*c*) Professors A. S. Berman, T. S. Lundgren.
(*d*) Theoretical and experimental; basic research; M.S., Ph.D. theses.
(*e*) Study of spin up with and without density stratification and free surfaces.

UNIVERSITY OF MINNESOTA, St. Anthony Falls Hydraulic Laboratory (see ST. ANTHONY FALLS HYDRAULIC LABORATORY listing).

UNIVERSITY OF MISSOURI — ROLLA, School of Engineering, Department of Chemical Engineering, Rolla, Mo. 65401. Dr. J. L. Zakin, Professor.

099-06404-250-00

EFFECT OF POLYMER STRUCTURE ON DRAG REDUCTION

(*c*) Dr. J. L. Zakin or Dr. G. K. Patterson.
(*d*) Experimental, basic research, M.S. thesis.
(*e*) The effectiveness of polymer additives in causing drag reduction is being studied in terms of molecular weight, molecular conformation, molecular structure and chain flexibility and concentration as well as mean velocity and diameter of conduit. The objective is to obtain quantitative relationships among these variables.
(*f*) Suspended.
(*g*) Previous work has shown that molecular conformation in solution, molecular weight, molecular structure and concentration, mean velocity and tube diameter all affect the level of drag reduction and the type of drag reduction observed in polymer solutions. Low values of the molecular rigidity, β, and high values of the entanglement capacity of the polymer chain, $m' = M/(M$ for critical entanglement) have been shown to be important for significant drag reduction.
(*h*) **Prediction of Drag Reduction with a Viscoelastic Model,** G. K. Patterson, J. L. Zakin, *AIChE J.* **14**, p. 434, 1968.
The Effect of Molecular Characteristics of Polymers on Drag Reduction, G. C. Liaw, J. L. Zakin, G. K. Patterson, *AIChE J.* **17**, p. 391, 1971.

099-06405-250-00

TURBULENCE INTENSITIES IN DRAG REDUCING ORGANIC SOLUTIONS

(*c*) Dr. J. L. Zakin or Dr. G. K. Patterson.
(*d*) Experimental; basic research.
(*e*) Details of the turbulence structure of drag reducing and non-drag reducing solutions are being investigated. Turbulence intensities, frequency spectra, integral scales and other turbulence quantities are being compared for drag reducing and non-drag reducing solutions.
(*g*) The results of turbulence measurements in solvents using wedge probes closely check the accepted values for measurements in air. A comparison of wedge, parabolic, cone and cylindrical hot-film probes showed the wedge and parabolic probes gave identical results while cone probes gave slightly low intensities. Cylindrical data were erratic because of eddy shedding. In viscoelastic solutions, high and low values of turbulence intensities are observed depending on the flow velocity. The frequency response of hot-film wedge probes was shown to be flat up to 100 cps so that frequency response of the probe cannot account for these discrepancies. Pressure probe intensity results were found to be inaccurate in viscoelastic fluids except at the center line of a tube.
(*h*) **Response of Hot-Film Wedge Probes in Viscoelastic Fluids,** J. M. Rodriguez, G. K. Patterson, J. L. Zakin, *Proc. Symp. on Turbulence Measurements in Liquids*, Univ. of Missouri–Rolla Continuing Education Series, 1971.
Measurement of Turbulence Intensities with Piezoelectric Probes in Viscoelastic Fluids, J. M. Rodriguez, G. K. Patterson, J. L. Zakin, *J. Hydronautics* **5**, p. 101, 1971.

099-06407-250-00

DRAG REDUCTION IN ORGANIC SOAP SOLUTIONS

(*c*) Dr. J. L. Zakin or Dr. G. K. Patterson.
(*d*) Experimental; basic research; M.S. thesis.
(*e*) While polymer solution drag reduction has been widely studied, little effort has been given to aluminum disoap additives which may be more effective drag reducers. The effect of soap type and concentration and the influence of flow variables (flow rate and diameter) are being investigated.
(*f*) Suspended.
(*g*) In aluminum disoap systems in non-polar solvents, diameter and velocity effects appear to be similar to those in polymer solutions. Soap solutions are sensitive to aging and under certain conditions to mechanical shear. Stabilizing additives can improve the shear resistance and aging of aluminum disoap solutions.
(*h*) **Effects of Age and Water Content on Drag Reduction in Aluminum Disoap-Hydrocarbon Solutions,** J. L. Zankin, *Nature: Phys. Sci.* **235**, p. 97, 1972.
Drag Reduction in Hydrocarbon-Aluminum Soap Polymer Systems, K. C. Lee, J. L. Zakin, presented *AIChE Symp. on Drag Reduction*, St. Louis, May 1972, published in *Drag Reduction in Polymer Solutions*, *AIChE Symp. Series* **69**, p. 45, 1973.

099-06408-120-00

VISCOSITY OF POLYMER SOLUTIONS

(*c*) Dr. J. L. Zakin or Dr. K. G. Mayhan.
(*d*) Experimental; basic research.
(*e*) The effects of polymer concentration, molecular weight, solvent-polymer interactions and polymer structure on viscosity are being investigated.
(*g*) Viscosity-concentration data of a number of polymer solutions in "good" solvents fit a single curve when plotted as $\eta_{sp}/C(\eta)$ vs. $k'(\eta)C$ up to the region of incipient molecular overlap. Data on "fair" solvent solutions also fit a single curve. Generalized curves over wider concentration ranges are obtained for η_R vs. $C(\eta)$ data.
(*h*) **Generalized Correlations for Molecular Weight and Concentration Dependence of Zero-Shear Viscosity of High Polymer Solutions,** in preparation.

099-07501-130-84

SOLID SUSPENSION DRAG REDUCTION

(*b*) Petroleum Research Fund of the American Chemical Society.
(*c*) Dr. J. L. Zakin or Dr. G. K. Patterson.
(*d*) Experimental, basic research, Ph.D. thesis.
(*e*) An investigation of the particle, fluid and flow variables influencing drag reduction in the flow of solid suspensions.
(*f*) Complete.
(*g*) Drag reduction in solid-liquid systems has been shown to be possible only with fibrous materials, contrary to previous reports in the literature. Increased 4/d and fiber flexibility both enhance drag reduction. Concentration effects are complex. There is a similarity between fiber-liquid drag reduction and particle-gas drag reduction results observed by some authors. The latter may be due to charge effects in the gas-solid systems and variations in charge effects may account for the variations in pressure drop results from system to system.
(*h*) **Drag Reduction in Solid-Liquid Suspensions in Pipe Flow,** I. Radin, J. L. Zakin, G. K. Patterson, *Nature Phys. Science* **246,** p. 11, 1973.
Drag Reduction in Solid-Fluid Systems, I. Radin, J. L. Zakin, G. K. Patterson, presented to *AIChE Mtg.*, Philadelphia, Nov. 1973, *AIChE J.*, in press.
Solid Fluid Drag Reduction, I. Radin, *Ph.D. Thesis*, Univ. of Missouri-Rolla, 1974.

099-07502-120-00

MEASUREMENT OF COMPLEX MODULUS IN DILUTE POLYMER SOLUTIONS

(*c*) Dr. Gary K. Patterson.
(*d*) Experimental, basic research, Ph.D. thesis.
(*e*) An instrument has been developed which is capable of measuring complex shear modulus at audio frequencies in dilute (below interaction) concentrations. Studies of effect of concentration and molecular weight dispersion on complex modulus are planned. The instrument has been modified to also accommodate soft solid materials so that shear modulus measurements may also be made on them.
(*f*) The instrument has been used for measurements in dilute polymer solutions and greases and seems to perform well, giving data of a reproducible character and similar to accepted literature data on solutions already measured. Preliminary results with soft solids show promise for this application as well.

099-07503-020-00

SEGREGATION INTENSITIES AND REACTION RATES IN A STIRRED-TANK REACTOR

(*b*) National Science Foundation.
(*c*) Dr. Gary K. Patterson.
(*d*) Theoretical, basic research, Ph.D. thesis.
(*e*) Segregation intensity and reaction conversion distributions are being measured and modeled for stirred-tank flow reactors under various conditions.
(*g*) Results of mixing and reaction conversion measurements are compared with the model calculations. Extension of the basic model to transient (unsteady) conditions has been made and a number of model computations for reactor upsets, batch operation, and semi-batch operation have been made. The model is being extended to include mixing effects on polymerization and fermentation reactions.
(*h*) **Segregation Intensity Distribution in Tank Mixer With and Without Second-Order Reaction,** G. K. Patterson, *Proc. Chemeca* 70, Butterworth's, Sydney, Australia, 1971.
A Fundamental Dynamic Response Model for CSTR's, G. K. Patterson, L. L. Otte, presented at *1st ISA Joint Spring Conf.*, St. Louis, Mo., Apr. 25, 1973.
Model With No Arbitrary Parameters for Mixing Effects on Second-Order Reaction With Unmixed Feed Reactants, G. K. Patterson, *Proc. ASME Mixing Symp.*, Atlanta, Ga., June 22, 1973.
Simulating Turbulent-Field Mixers and Reactors or Taking the Art Out of the Design, G. K. Patterson, presented at *77th Natl. AIChE Mtg.*, Pittsburgh, June 1973, a chapter of *Application of Turbulence Theory to Mixing Operations*, ed. by R. S. Brodkey, Acad. Press, N. Y., in press.
Simulation and Scale-Up of Turbine and Propeller Agitated Vessels, G. K. Patterson, *Proc. BHRA Symp. on Mixing and Separation*, Cambridge, Sept. 1974.
Modellzur Computer-Berechnung des Turbulenten Mischens mit Reaktionen 2. Ordnung, G. K. Patterson, *Chemie-Ingenieur-Technik* **46,** p. 999, 1974.
Turbulence Level Significance of the Monte-Carlo Interaction Parameter, R. M. Canon, A. W. Smith, K. W. Wall, G. K. Patterson, submitted to *Chem. Eng. Sci.*
Average Molecular Weight Distributions in Stirred-Tank Reactors By a Random Coalescence-Dispersion Simulation, G. K. Patterson, presented at *78th Natl. AIChE Mtg.*, Houston, Tex., Mar. 1975.

099-08861-050-15

COHERENCE OF HIGH PRESSURE JETS

(*b*) U. S. Army Mobility Equipment Res. and Dev. Ctr., Fort Belvoir.
(*c*) Dr. J. L. Zakin or Dr. D. A. Summers.
(*d*) Experimental, applied research, M.S. thesis.
(*e*) The effects of pressure, nozzle size, fluid properties and traversing speed on the coherence length of high pressure turbulent liquid jets are being studied. Such jets are useful in cutting, mining, drilling and earth moving.
(*g*) The influence of pressure and nozzle size on jet coherence varies depending on the jet Reynolds number range. The addition of small amounts of certain viscoelastic additives to the liquid greatly increases the coherent length of the jet.
(*h*) **The Effect of Pressure, Jet Diameter and Viscoelastic Additives on High Velocity Jet Structure and Cutting Ability,** D. A. Summers, J. L. Zakin, presented to *67th Ann. AIChE Mtg.*, 1974.

UNIVERSITY OF MISSOURI — ROLLA, Department of Civil Engineering, Rolla, Mo. 65401. Joseph H. Senne, Department Chairman.

101-06287-810-00

MODIFIED STATION-YEAR METHOD FOR FLOOD FREQUENCIES

(*c*) Dr. T. E. Harbaugh.
(*d*) Design.
(*e*) Determination of flood peaks for small drainage areas in Missouri based on physiographic data.

101-07504-200-00

EFFECTS OF RAINDROP IMPACT ON OVERLAND FLOW

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Experimental.
(*e*) Work is being performed in the laboratory to determine the effect of raindrop impact as a contributing factor in the resistance to flow for short overland flow conditions.
(*h*) Ph.D. dissertation pending.

101-07505-350-88

TIME SEQUENCED DAM FAILURES

(*b*) National Defense Education Act.
(*c*) Dr. T. E. Harbaugh.
(*d*) Experimental.
(*e*) Determination of the influence of a controlled breaking of a dam upon the ensuing downstream flood wave.
(*h*) Ph.D. dissertation completed.

101-07506-220-33

EVALUATION OF A SINGLE LAYER OF GRADED GRAVEL AS A PROTECTIVE FILTER ON EMBANKMENT SLOPES

(*b*) Office of Water Resources Research.
(*c*) C. D. Muir, Assoc. Professor.
(*d*) Experimental.
(*e*) Determine the effect of thickness and gradation on the ability of a single graded filter layer to prevent the migration of finer particles through the layer.
(*h*) Master's thesis completed.

101-07507-200-00

A SENSITIVITY ANALYSIS OF THE SPATIALLY VARIED UNSTEADY FLOW EQUATIONS

(*c*) Dr. T. E. Harbaugh.
(*d*) Theoretical.
(*e*) Computer solutions of the spatially varied flow equations are being performed for various boundary, finite difference, mesh sizes, and inputs to determine the sensitivity of the equations to a variety of parameters.
(*h*) Ph.D. dissertation (G. T. Stevens, Jr.) completed.

101-08862-220-13

VELOCITY DISTRIBUTION VERSUS SEDIMENT IN THE MISSOURI RIVER

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research.
(*e*) An attempt was made to fit experimentally developed sediment transport equations to the Missouri River.
(*f*) Completed.

101-08863-300-13

THE MISSOURI RIVER COMPUTERIZED DATA BANK

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research.
(*e*) Collection and storage of all available velocity and sediment data that is needed in the development of a typical Missouri River velocity and sediment concentration profile. These profiles then can be utilized in a sediment transport relationship for the Missouri River.

101-08864-810-00

UNIT HYDROGRAPH FOR OZARK SECTION OF SOUTHWEST MISSOURI

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design.
(*e*) Development of a synthetic unit hydrograph for the Ozark section of Missouri and Arkansas using readily available physiographic data.
(*h*) Master's thesis pending.

101-08865-310-00

A MULTIPLE-PLAN EVALUATION MODEL FOR SMALL UNGAGED WATERSHEDS

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design.
(*e*) A computer model for simulation of the effect of alternative measures for flood damage reduction. The goal is to optimize the value of an objective function which will maximize the amount of net benefits returned by the project.
(*h*) Completed Master's thesis, J. R. Dexter.

101-08866-810-00

A COMPARISON OF THREE URBAN HYDROLOGY MODELS

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design, Master's thesis.
(*e*) A comparison of three models used for the calculation of urban stormwater runoff is presented. Simulation results are based on the capability of these models to reproduce observed peak discharges, time to peak and the direct runoff volume.
(*h*) Completed Master's thesis, R. F. Astrack.

101-08867-810-00

A STATISTICAL HYDROLOGIC SIMULATION MODEL

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research, design.
(*e*) A simulation model for small watersheds using probabilistic models derived from short term rainfall – runoff records are developed. The model is used to generate a synthetic flood series which is compared to the observed flood series.
(*h*) Completed Master's thesis, R. L. Wycoff.

101-08868-350-00

RESERVOIR DESIGN: SIMULATION TECHNIQUES

(*c*) Dr. G. T. Stevens.
(*d*) Design, applied research.
(*e*) A computerized simulation model using hydrologic routing techniques is developed to aid in the analysis of small dams to reduce the possibility of inadequate spillway design. Simulation equation derived from the continuity equation to describe reservoir storage and outflow. Newton's iteration technique is utilized to solve the simulation equations. The resulting model determines an optimum size auxiliary spillway having a minimum crest length for a range of spillway elevations.
(*h*) Completed Master's thesis, L. W. Mays.

101-08869-880-13

MISSOURI RIVER ENVIRONMENTAL INVENTORY

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. P. R. Munger.
(*d*) Field investigation.
(*e*) Study was conducted to obtain baseline information which could be used in preparation of an operation and maintenance environmental impact statement by the Corps. The investigation consisted of a literature review and selected field studies of the aquatic ecosystems and natural resources bordering the river.
(*f*) Completed.

101-08870-880-13

A BASE LINE STUDY OF THE MISSOURI RIVER

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. P. R. Munger.
(*d*) Field investigation.
(*e*) To increase the understanding of the interrelationships which exist between the activities conducted by the Corps of Engineers in, on, and in the vicinity of, the Missouri River and the environment of the region traversed.
(*f*) Completed.

101-08871-870-00

ENVIRONMENTAL INVENTORY AND ASSESSMENT OF AREAS I, II, III, AND IV, ARKANSAS RIVER CHLORINE CONTROL PROJECT, OKLAHOMA AND KANSAS

(*c*) Dr. Ju-Chang Huang.
(*d*) Field investigation.
(*e*) Collect background information of environmental resources, including geological feature, hydraulic and hydrological characteristics, water quality, socio-economical conditions, aquatic and terrestrial biology, etc., of the four study areas associated with the Arkansas River Chloride Control Project. Assessments of potential environment impacts which will be incurred as a result of the chloride control project implementation will be made in this investigation.

MONTANA STATE UNIVERSITY, Department of Agricultural Engineering, Agricultural Experiment Station, Bozeman, Mont. 59715. Professor William E. Larsen, Department Head.

102-08161-840-31

SURFACE IRRIGATION HYDRAULICS

(*b*) U. S. Bureau of Reclamation.
(*c*) Professor C. C. Bowman.
(*d*) Research is based on theoretical and field investigations. The theoretical phase has been completed and it is now being applied to field conditions.
(*e*) Theoretical equations were developed for computing the flows required to give efficient application of water by surface flow systems. Curves are now being developed for application as design and management tools. Automation of systems is also included in these studies.
(*g*) Equation has been developed to compute flows necessary for efficient distribution of waters for surface irrigation. Project in final stage of completion.

MONTANA STATE UNIVERSITY, Department of Civil Engineering and Engineering Mechanics, College of Engineering, Bozeman, Mont. 59715. Dr. Glen L. Martin, Department Head.

103-0116W-800-00

DEVELOPMENT OF A STATE WATER PLANNING MODEL

(*e*) See WRRC 7, 6.0754.
(*f*) Completed.
(*h*) Final Report January 1973.

103-07513-260-06

PIPELINE TRANSPORT OF WOODCHIP AND WATER MIXTURES

(*b*) U.S. Dept. of Agriculture, Forest Service.
(*c*) Dr. W. A. Hunt.
(*d*) Theoretical and experimental studies of applied research on 2000-ft test loop of 8-in. dia. pilot line.
(*e*) Obtain head loss correlations for mixtures of woodchips and water in pipelines; development of mechanical injection system for woodchips; preliminary analysis of corrosion effects of mixtures of water and woodchips on steel pipes; operation of remote pump in by-pass line; compilation of data for design and operation of woodchip pipelines.
(*f*) Experimental studies completed November 1974.
(*g*) Friction losses appear to correlate best as Weisbach friction factor f as a function of V^2/gD for data on 3-, 4-, 6-, 8- and 12-in. pipes; intermittent operation of booster pumps in a by-pass line was not successful; critical velocity criteria established; corrosion effects may be determined by polarization curves.
(*h*) Final Report February 1975.

103-08162-800-61

OPERATIONS MODEL FOR MONTANA'S WATER RESOURCES

(*e*) See WRRC 8, 6.0823.
(*f*) Completed.
(*h*) **Sequential Optimization of Multiple Non-Monetary Objectives in the Operation of Reservoir** Systems, G. V. V. Rao, *Ph.D. Thesis*, Montana State Univ., 1974. Final Report pending.

103-08163-370-47

HYDROLOGIC AND HYDRAULIC RESEARCH FOR CULVERT DESIGN

(*b*) Montana Department of Highways and Federal Highway Administration.
(*c*) Dr. E. R. Dodge.
(*d*) Field investigation, theoretical and applied research.
(*e*) A statistical analysis of peak annual floods from 231 Montana watersheds and a regression analysis of the flood frequency data and watershed parameters were used to develop a set of flood peak prediction equations for floods with recurrence intervals from 2 to 50 years. The equations contain such independent variables as drainage areas, mean annual precipitation, percent forest cover, percent drainage area over 6000 ft msl, intensity of 24 hr duration 2-year recurrence interval rainstorm, and an SCS hydrologic soil index number. Not more than three independent variables are used for any geographic region with drainage area always one of these. Charts were developed from which the flood flows may be directly read. The equations are now used by the Montana Department of Highways to determine design discharges for small hydraulic structures, primarily culverts. Final report includes a description of up-to-date procedures for hydraulic design of culverts.
(*f*) Completed.
(*g*) Prediction equations for the 2-, 5-, 10-, 25-, and 50-year recurrence interval flood peaks have been developed for the nine regions of Montana. Confidence limits charts which were also developed for each geographic region permit the designer to realistically use his professional engineering judgement in the final selection of a design flow. Hydraulic design procedures for determining the flow capacity of any trial selection for a culvert site are covered in detail.
(*h*) Final report September 1972.

103-08872-820-61

IMPACT OF LAND USE CHANGE ON THE GROUNDWATER RESOURCES OF THE BOZEMAN, MONTANA AREA

(*b*) Montana University Joint Water Resources Research Center.
(*c*) Dr. R. L. Brustkern.
(*d*) Theoretical study of an applied research project for a M.S. degree.
(*e*) Impact of land use changes in an area of rapid devlopment around Bozeman, Montana, are under study. A groundwater model using finite difference techniques is being developed to investigate the effects of projected land use changes on the groundwater flows.

NEW JERSEY INSTITUTE OF TECHNOLOGY, Newark College of Engineering, Department of Mechanical Engineering, Newark, N. J. 07102. Dr. Robert A. Comparin, Department Head.

104-09646-600-12

INVESTIGATION OF THE MECHANICS OF DEPOSITION OF CONTAMINATION IN A FLUID AMPLIFIER

(*b*) Department of the Army, Harry Diamond Laboratories.
(*d*) Theoretical and experimental; applied research for a Doctoral dissertation.
(*e*) The deposition of contaminants in fluidic devices can significantly change the performance characteristics of the devices. The purpose of this investigation is to analyze the mechanics of deposition so that reliability can be predicted and to provide a basis for design changes to improve resistance to contamination effects.
(*g*) Project still in preliminary stages.
(*h*) A report will be available late in 1975 from the Harry Diamond Laboratories or from the project director.

104-09647-000-00

FLOW IN THE ENTRANCE REGION AT LOW REYNOLDS NUMBERS

(*c*) Dr. R. Y. Chen, Associate Professor.
(*d*) Basic research.

(*e*) Incompressible laminar flow in the entrance region of a parallel-plate channel and a circular tube is analyzed with momentum integral method.
(*f*) Completed.
(*g*) Entrance length and pressure drop are function of Reynolds number. Approximate solutions in closed form are given.
(*h*) **Flow in the Entrance Region at Low Reynolds Numbers,** R. Y. Chen, *J. Fluids Engrg. Trans. ASME* **95,** Series 1, 1, pp. 153-158, Mar. 1973.
Slip Flow in the Entrance Region at Low Reynolds Numbers, R. Y. Chen, *Trans. ASME, J. Fluids Engrg.*, in print June 1975.

104-09648-120-00

STUDY OF TIME-DEPENDENT NON-NEWTONIAN FLOWS

(*c*) Dr. P. J. Florio, Assistant Professor.
(*d*) Doctoral thesis.
(*e*) An analytical study of the effects of the development of the flow field of an incompressible, non-Newtonian fluid entering a rigid circular tube subject to the condition that at the physical entrance to the tube the velocity possesses both an oscillating and a non-zero mean velocity. The type of fluid studied is one whose steady rheological behavior follows the Sisko model.

104-09649-000-00

INVESTIGATION OF FLOW INSTABILITIES AND TRANSITION BY THERMODYNAMIC (STOCHASTIC) METHODS

(*c*) Dr. Peter Hrycak, Professor.
(*d*) Theoretical and applied research.
(*e*) By application of Meissner's Entropy Principle, the problem becomes one of thermodynamics. Some results of irreversible thermodynamics become immediately applicable (like the Theorem of Entropy Production). Calculation of the point of instability and the critical Reynolds number becomes a definite possibility.
(*h*) **Critical Reynolds Number Motivated Interaction Between Test Set-Up and the Environment,** P. Hrycak, M. M. Levy, *Proc. Inst. Environ. Sci.*, pp. 397-402, 1973.
Critical Reynolds Number Estimates by Thermodynamic (Stochastic) Methods, P. Hrycak, M. J. Levy, *ASME Trans.* **96,** Ser. B, pp. 788-794, 1974.
Analysis of Instabilities in Round Pipes and Infinite Channels, P. Hrycak, *Intl. J. Heat and Mass Transfer* **17,** pp. 869-873, 1974.
Calculation of Critical Reynolds Number in Round Pipes and Infinite Channels and Heat Transfer in Transition Region, P. Hrycak, R. Andrushkiw, *Proc. 5th Intl. Heat Transfer Conf.* **II,** pp. 183-187, Tokyo, Japan, 1974.
Test Object-Environment Interaction in External Flows, P. Hrycak, R. Andrushkiw, M. J. Levy, *Proc. Inst. Environ. Sci.*, pp. 252-256, 1974.
Biological Flow Transition Analysis by Thermodynamic Methods, M. J. Levy, P. Hrycak, *Proc. 27th Ann. Conf. Engrg. in Medicine and Biology* **16,** p. 208, 1974.

104-09650-050-00

PHENOMENOLOGICAL INVESTIGATION OF JET FLOW PHENOMENA

(*c*) Dr. Peter Hrycak, Professor.
(*d*) Experimental and applied research, Ph.D. and M.S. thesis research.
(*e*) By using miniature probes, the free jets, wall jets, and impinging jets are investigated concerning velocity distribution in a free and developing jet, boundary layer thickness in a given geometry, and their applications for high intensity cooling or heating.
(*h*) **Survey of Literature on Flow Characteristics of a Single Turbulent Jet,** P. Hrycak, J. W. Gauntner, J. N. B. Livingood, *NASA TN D-5652*, 1970.
Flow Characteristics of an Air Jet Impinging on a Flat Surface, P. Hrycak, *NASA Tech. Brief 70-10670*, Dec. 1970.
Experimental Flow Characteristics of a Single Turbulent Jet Impinging on a Flat Plate, P. Hrycak, D. T. Lee, J. W. Gauntner, J. N. B. Livingood, *NASA TN D-5690*, 1970.
Calculation of Maximum Velocity Decay in Wall Jets, P. Hrycak, D. T. Lee, *J. Spacecraft and Rockets* **7,** 5, pp. 623-625, 1970.
Impingement Heat Transfer from Turbulent Air Jets to Flat Plates, A Literature Survey, J. N. B. Livingood, P. Hrycak, *NASA TM X-2778*, 1973.
A Study of Characteristics of Developing Incompressible, Axi-Symmetric Jets, P. Hrycak, S. Jachna, D. T. Lee, *Letters in Heat and Mass Transfer* **1,** pp. 63-72, 1974.

104-09651-270-54

EXPERIMENTAL INVESTIGATION OF TURBULENCE IN THE CONTEXT OF ARTERIAL HEMODYNAMICS

(*b*) Partially sponsored by the National Science Foundation and by the Middlesex County Heart Association.
(*c*) Dr. H. E. Pawel, Associate Professor.
(*d*) Experimental, applied research, for Doctoral thesis.
(*e*) Turbulence aspects of arterial hemodynamics were experimentally investigated in a physical model with pulsatile flow through a distensible tube. Hot-film anemometry was used.
(*f*) Completed.
(*g*) Spectral analysis of velocity data by FFT techniques indicates the presence of short bursts of turbulence just following systole at a normal heart rate, and more developed, less quickly decaying turbulence, with significant spectral components at frequencies near 1000 Hz, at a heart rate of 112 beats per minute. These findings suggest that characteristic components in the energy spectra may be identifiable for use in diagnostic techniques.
(*h*) **Spectral Analysis of Turbulence in Simulated Arterial Flow,** H. E. Pawel, R. L. Peskin, *Proc. 27th Ann. Conf. Engrg. in Medicine and Biology*, p. 204, Oct. 1974.
Higher Frequency Study of Simulated Arterial Turbulence, H. E. Pawel, R. L. Peskin, *ASME Paper 74-WA/Bio-9*, Nov. 1974.

104-09652-270-00

INVESTIGATION OF SOUNDS PRODUCED BY ARTERIAL FLOW DISTURBANCE

(*c*) Drs. H. E. Pawel and C. Wilson, Associate Professors.
(*d*) Experimental, applied research.
(*e*) Relationships between patterns and spectra of externally monitored sounds to internal arterial velocity fields are explored with a view to applications in non-invasive diagnostic techniques.

UNIVERSITY OF NEVADA, Desert Research Institute (see DESERT RESEARCH INSTITUTE listing).

NEW YORK OCEAN SCIENCE LABORATORY of Affiliated Colleges and Universities, Incorporated, Drawer EE, Montauk, N. Y. 11954.

105-08954-470-00

MODEL STUDY OF MONTAUK HARBOR

(*c*) Dr. Thore Omholt, Assoc. Research Scientist, Hydraulic Engineering.
(*d*) Experimental; applied research.
(*e*) A vertically distorted Froude model of Montauk Harbor is being operated. The purpose of the model is to study the tidal flow in the harbor and changes in the flow pattern resulting from modifications in its physiographic features.
(*h*) New York Ocean Science Laboratory Technical Report (in preparation).

105-08955-460-00

INVESTIGATION OF THE LAMINAR SUBLAYER AT THE AIR-SEA INTERFACE

(*c*) Dr. Thore Omholt, Assoc. Research Scientist, Hydraulic Engineering.
(*d*) Theoretical.
(*e*) The influence of wind on the thickness of the laminar sublayer at the air-sea interface is investigated.
(*g*) Surface tension appears to be an important factor in determining the sublayer thickness.
(*h*) **Estimation of the Oceanic Momentum Sublayer Thickness,** T. Omholt, *J. Phys. Ocean.* **3**, pp. 337-338, 1973.

105-08956-450-00

CIRCULATION OF THE WATERS OF BLOCK ISLAND AND EASTERN LONG ISLAND SOUND

(*c*) Dr. Rudolph Hollman, Sr. Research Scientist, Physical Oceanography.
(*d*) Experimental, applied research.
(*e*) An umbrella study that includes the analysis of current meter data, physical data, drogue tracking, tidal exchanges, and wind field in an attempt to better understand the circulation of these waters as it relates to tidal action, wind action, and hydraulic forces.
(*g*) The net flow along the northern and southern boundaries of Block Island Sound is in the flood direction (west), whereas in the center area the net flow is in the ebb direction. In general, the surface flow is directed out of the Sound, part of which attaches to the longshore current moving west along the south shore of Long Island; the bottom flow is directed into the Sound (west). Turbulent parameters show the influence of annual variations in the wind field and hydraulic forces.
(*h*) **Tidal Currents and Water Exchanges in Western Block Island Sound,** R. E. Meguire, Jr., *Master's Thesis*, Long Island Univ., Dept. of Marine Science, 1971.
The Residual Drift in Eastern Long Island Sound and Block Island Sound, R. Hollman, G. Sandberg, *N. Y. Ocean Science Lab. Tech. Rept. 15*, 1972.
Annual Low Level Wind Distribution, R. Hollman, *N. Y. Ocean Science Lab. Tech. Rept. 30*, 1975.

POLYTECHNIC INSTITUTE OF NEW YORK, Department of Civil Engineering, 333 Jay Street, Brooklyn, N. Y. 11201. Henry F. Soehngen, Department Head.

106-08873-300-00

STREAMFLOW ROUTING UNDER LOW FLOW CONDITIONS

(*c*) Dr. Alvin S. Goodman.
(*d*) Theoretical, applied research; Doctoral thesis.
(*e*) Develop a computational method to estimate flow characteristics such as stage, velocity and discharge at any stream section, given values of these variables at an upstream location. Low flow conditions are assumed with unsteady, spatially varied flow. Surface runoff from rainstorms and snowmelt are not operative, and groundwater distributions and local interflows are basic variables affecting streamflow.
(*g*) A theoretical framework has been completed, and a computer program is being developed to define the computational method and to confirm its usefulness by application to actual field data.

STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Engineering Science, Aerospace Engineering and Nuclear Engineering, Buffalo, N. Y. 14214. Dr. Richard P. Shaw, Professor.

107-08171-470-00

HARBOR RESONANCE

(*d*) Theoretical, basic research at SUNYAB combined with experimental at the University of Hawaii.
(*e*) Response of harbors to incident long-period water waves is examined in order to determine effects of harbor geometry, depth, etc., on resonance wavelengths and amplification factors. Present aim is to examine effects of friction, variable depth and interconnected basins. A related experimental project presently carried out at the U. of Hawaii is to develop an acoustic analog to such problems.
(*g*) Effects of variable slope and sidewall/bottom friction in entrance channel have been studied. Friction counteracts amplification effect of increased channel length.
(*h*) **Channel Friction and Slope Effects on Harbor Resonance,** R. P. Shaw, C. K. Lai, *Proc. ASCE* **100**, WW3, pp. 205-215, Aug. 1974.

STATE UNIVERSITY OF NEW YORK AT BUFFALO, Fluid and Thermal Sciences Laboratory, Buffalo, N. Y. 14214. Dr. Godon Hall, Laboratory Director.

108-08173-270-84

BLOOD FLOW IN THE AORTA OF DOGS

(*b*) Heart Association of Southwestern New York.
(*d*) Experimental, basic research for M.S. thesis.
(*e*) Measure the instantaneous velocity profiles in the aortas of dogs using hot-film anemometry techniques, and to compare these profiles with available theory.
(*g*) In general the measurements confirm the observation that the velocity profiles tend to be flat with the highest rates of shear confined to the region of the wall. There are however significant variations in the details of the flow from one dog to another. The general shapes of the profiles at least during early systole, resemble those of a tube flow started impulsively from rest.
(*h*) **Sequential Velocity Profile Development in the Ascending and Descending Aorta of the Dog,** H. L. Falsetti, K. M. Kiser, G. P. Francis, E. R. Belmore, *Circ. Res.* **XXXI**, p. 328, 1972.
Oscillatory Flow in the Aorta of Dogs, K.-H. Yu, *M.S. Thesis*, available Univ. Library.
Velocity Wave Forms in the Dog Aorta, K. M. Kiser, G. P. Francis, H. L. Falsetti, R. J. Carrol, *Proc. 5th Ann. Pittsburgh Conf. on Modeling and Simulation*, pp. 951-956, 1974.

108-09283-440-00

PHYSICAL MODELING OF THE GREAT LAKES

(*c*) Ralph R. Rumer, Professor, Dept. of Civil Engineering and Kenneth M. Kiser, Assoc. Professor, Dept. of Chemical Engineering.
(*d*) Theoretical and experimental basic research at the M.S. and Ph.D. level.
(*e*) Determine the circulation and the dispersion phenomena in large lakes, particularly the Great Lakes of North America using physical models. Wind-stress through flow, stratification and Coriolis force effects are considered.
(*h*) **Circulation Patterns and a Predictive Model for Pollutant Distribution in Lake Erie,** J. H. Howell, K. M. Kiser, R. R. Rumer, *Proc. 13th Conf. Great Lakes Res. 1970*, pp. 434-443.
Hydraulic Model Study of Subsurface, Wind Driven Currents in Lake Erie During Summer Stratification, G. A. Peck, *M.S. Thesis*, available Univ. Library.
Subsurface Circulation Patterns on a Rotating Model of Lake Erie, W. A. Pomerhn, *M.S. Thesis*, available Univ. Library.

Physical Model Study of Circulation Patterns in Lake Ontario, C-Y. Li, K. M. Kiser, R. R. Rumer, *Limnology and Oceanography*, 1975.
Hydraulic Model Study of Surface and Sub-Surface Wind-Driven Currents in Lake Ontario, C-Y. Li, *Ph.D. Dissertation*, available Univ. Library.

108-09284-050-00

MODELING OF TURBULENT AXISYMMETRIC COFLOWING STREAMS AND QUIESCENT JETS: A REVIEW AND EXTENSION

(*c*) Kenneth M. Kiser, Assoc. Professor of Chemical Engineering.
(*d*) Theoretical applied research at Ph.D. level.
(*e*) Most recent efforts at modeling the flow fields in axisymmetric turbulent jets are reviewed. Turbulent shear stress models are developed to predict mixing over a wide range of flow conditions.
(*f*) Completed.
(*h*) *Ph.D. Dissertation*, S. W. Zelazny, available Univ. Library.

108-09285-210-00

PULSATILE FLOW IN RIGID TUBES

(*c*) Kenneth M. Kiser, Assoc. Professor of Chemical Engineering.
(*d*) Experimental, basic research at M.S. and Ph.D. levels.
(*e*) Velocity fields were measured in a tube flow for laminar and turbulent flow. Both entrance flow and fully developed flow were examined.
(*f*) Suspended.
(*h*) **An Experimental Investigation of Velocity Profiles for Laminar and Turbulent Pulsatile Flows in a Rigid Tube,** J. A. Klapetsky, *M.S. Thesis*, available Univ. Library.
An Experimental Investigation of the Inlet Length for Pulsatile Flow in a Rigid Tube, *Ph.D. Dissertation*, available Univ. Library.

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STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Mechanical Engineering, Buffalo, N. Y. 14214. Gerald P. Francis, Department Chairman.

109-08874-060-33

NUMERICAL MODELING OF HEATED DISCHARGES AND MEASUREMENTS OF THEIR MIXING COEFFICIENTS

(*b*) Office of Water Research and Technology, U. S. Dept. of the Interior.
(*c*) Lawrence A. Kennedy, Associate Professor.
(*d*) Theoretical and experimental, applied research.
(*e*) A mathematical model for a heated discharge into a cross flow is being developed. Vertical mixing coefficients at the interface between the heated discharge and cool underlying water will be obtained through laboratory measurements. Heated plume dispersion will be determined for a range of cross currents and discharge parameters. This project seeks to improve methods for predicting the behavior of heated discharges.

109-08875-290-00

GAS-PARTICLE COMBUSTION.

(*c*) Lawrence A. Kennedy, Associate Professor.
(*d*) Experimental; basic research for Doctoral thesis.
(*e*) The combustion of gas-particles (coal dust) is being examined in a vortex stabilized combustor which allows a high mass flux of coal to be burnt. The combustion can be controlled to run in either the fuel rich or air rich mode. The latter operates as an efficient direct combustion device. The former can be utilized to gasify the coal. Both approaches utilized the rapid devolatilization of the coal particles.

109-08876-290-00

THERMAL FIELDS IN ENCLOSURES

(*c*) Lawrence A. Kennedy, Associate Professor.
(*d*) Theoretical and experimental; basic research for Doctoral thesis.
(*e*) Natural convection associated with the flow in enclosures is examined for vertical corridors and cavities having various surface heat transfer rates and/or surface temperatures. Numerical models are developed and are being compared with interferometric measurements. Purpose of this study is to better understand these flows which have an application to fire propagation and cooling of electronic components.

109-08878-070-00

LABORATORY MODELING OF THERMAL FIELDS IN A POROUS MEDIA

(*c*) Lawrence A. Kennedy, Associate Professor.
(*d*) Experimental; basic research for Master's thesis.
(*e*) Optical measurements of the temperature fields in porous flows is examined through the use of the Christiansen effect. Factors influencing its accuracy are being examined.

109-08879-870-60

CONTAINMENT AND COLLECTION OF MARINE OIL SPILLS

(*b*) New York State Sea Grant Program.
(*c*) J. Gordon Hall, Professor.
(*d*) Theoretical – a critical survey; applied research; Master's thesis.
(*e*) A critical review of the current state-of-the-art technology for containment and collection of marine oil spills, with particular concern for pollution hazards on the Atlantic seaboard.

109-08880-140-54

FLOW IN MECHANICALLY ENHANCED HEAT TRANSFER CONDUITS

(*b*) National Science Foundation.
(*c*) Yan-Po Chang, Professor.
(*d*) Analytical study; basic research for Ph.D. dissertations.
(*e*) The laminar flow in corrugated, internally finned and heated conduits of circular and non-circular cross-sections is investigated theoretically. A system of momentum and energy equations is formulated for finned regions which are, in general, irregular and unequal and are coupled with mixed boundary conditions. Each unequal and irregular domain is transformed into one of a circular sector. By the use of Green's functions, the mixed boundary conditions are replaced by unmixed ones and the problem becomes one of the solution of a smaller number of integral equations for the unknown boundary values.
(*f*) Completed.
(*g*) The heat transfer coefficients can be as high as 20 times those for flow in plain conduits.
(*h*) **Optimization of Finned Tubes for Heat Transfer in Laminar Flow,** M. H. Hu, Y. P. Chang, *Trans. ASME* **95**, Ser. C. 2, pp. 332-338, 1973.
Flow in Internally Finned Tubes of Non-Circular Cross-Sections, D. T. W. Chen, *Ph.D. Dissertation*, Univ. Microfilms, Ann Arbor, Mich., Dec. 1973.

109-08881-210-00

FLOW IN POROUS, HEATED CONDUITS

(*c*) Yan-Po Chang, Professor.
(*d*) Analytical study; basic research for Ph.D. dissertations.
(*e*) The steady, laminar, incompressible and compressible flow in the entrance region of heated conduits with uniform injection or suction is investigated by a linearized method with the transverse velocity taken into account. For incompressible flow, velocity, temperature and other hydrodynamic and thermal characteristics are obtained in

series of confluent hypergeometric functions. A similar method is applied to compressible flow but calculation has not been completed.
(*f*) Completed for incompressible flow.
(*g*) Calculated results for incompressible flow between two semi-infinite parallel plates and in a semi-infinite circular tube are in good agreement with those obtained by the numerical solution of the governing differential equations.
(*h*) **A Linearized Analysis of Flow and Heat Transfer in Porous Conduits,** R. C. H. Tsou, *Ph.D. Dissertation*, Univ. Microfilms, Ann Arbor, Mich., May 1974.

STATE UNIVERSITY OF NEW YORK AT STONY BROOK, Marine Sciences Research Center, Stony Brook, N. Y. 11794. Malcolm J. Bowman, Assistant Professor.

111-09001-870-00

POLLUTION TRANSPORT MECHANISMS IN THE EAST RIVER, NEW YORK

(*b*) The Research Foundation of the State University of New York.
(*d*) Experimental and theoretical; applied research.
(*e*) Investigate the complex tidal, estuarine, and non-tidal transport mechanisms of the East River. These mechanisms are responsible for the transport of large quantities of sewage effluents, originating in the New York Harbor and the East River itself, into Long Island Sound. Although the tidal characteristics of the East River, as a hydraulic tidal strait, are relatively well-documented, the historical data on the non-tidal fluxes are extremely confused. A large collection of tidal, current, meteorological and sewage data is held by various governmental and city agencies. These data are being analyzed using established hydrodynamical methods to understand and quantify these various mechanisms. These results will enable more accurate estimates to be made of sewage effluent flux from the East River into Long Island Sound.
(*g*) About 400 MGD of sewage effluent is transported by the East River into western Long Island Sound. This represents ~ 32 percent directly into the entire Sound. This figure also represents ~ 70 percent of effluents released from the four sewage plants in the Upper East River. The remaining 30 percent is transported to New York Harbor.
(*h*) **Hydraulic characteristics of the East River, New York,** M. J. Bowman, R. E. Wilson, A. S. Robbins, *Trans. Amer. Geophys. Union* **56,** 2, p. 83, Feb. 1975.

111-09002-870-60

MANAGEMENT MODEL FOR WESTERN LONG ISLAND SOUND

(*b*) The New York State Sea Grant Program.
(*d*) Experimental and theoretical; applied research.
(*e*) Develop a one-dimensional, steady state, water, salt and effluent balance model of Long Island Sound to describe the transport and decay of water borne dissolved contaminants whose principal sources are sewage treatment plants located in the region. Inorganic nutrients were used as convenient tracers of sewage effluent. Nutrient inputs from agricultural and oceanic sources were also included. The predicted values of nutrient concentrations represent the combined effects of tidal dispersion, advected transport, and first order biochemical decay.
(*f*) Completed.
(*g*) Close agreement between theoretical and experimental distributions were obtained. High concentrations of sewage effluent are found in western Long Island Sound, but drop rapidly to relatively constant levels in central and eastern Long Island Sound. Nutrients migrate eastward from the western end until consumed by organisms at exit to the ocean at The Race. Biochemical decay is from 10 to 100 times more rapid in summer than in winter, although source concentrations are much the same. Nutrient inputs from agricultural sources are negligible compared with sewage sources.
(*h*) **Pollution Prediction Model of Long Island Sound,** M. J. Bowman, *Proc. Ocean Engrg. III Conf., ASME*, Delaware, June 9-13, 1975.

NIELSEN ENGINEERING AND RESEARCH, INCORPORATED, 510 Clyde Avenue, Mountain View, Calif. 94043. Dr. Jack N. Nielsen, President.

112-08185-400-33

APPLICATION OF TURBULENT BOUNDARY-LAYER THEORY TO DISPERSION IN ESTUARIES

(*b*) Office of Water Resources and Technology.
(*d*) Theoretical; applied research.
(*e*) To utilize turbulent boundary-layer theory to model velocity profiles and dispersion in real well-mixed estuaries. The three-dimensional theory is applied together with a tidal prediction method to a three-dimensional estuary model for which data are available.
(*f*) Completed.
(*g*) A theory was developed for calculating the complete velocity field of long well-mixed estuaries which vary in cross section. The method is based on boundary-layer theory in that vertical profiles of velocity in the estuary are assumed to have the analytical form characteristic of turbulent boundary layers. Lateral variation of the vertically averaged velocity and bottom shear stress are calculated with the help of data obtained from a tidal model. Good comparisons are achieved with available data from real estuaries. The velocity theory was used to develop a method for calculating dispersion coefficients for use in a gross diffusion equation for estimating the dispersion of pollutants in the estuary. Subsequent dispersion calculations indicated that the coefficients adequately predicted the dispersion of dye measured in the U. S. Army Engineers Delaware River Model.
(*h*) **Application of Boundary-Layer Theory to Dispersion in Non-Stratified Two-Dimensional Estuaries,** J. N. Nielsen, G. D. Kuhn, *NEAR TR* **45,** Aug. 1973.
Application of Boundary-Layer Theory to Dispersion in Well-Mixed Estuaries, G. D. Kuhn, J. N. Nielsen, *NEAR TR* **63,** Sept. 1974.

NORTH CAROLINA STATE UNIVERSITY AT RALEIGH, Department of Research Administration, Raleigh, N. C. 27607. Earl G. Droessler, Dean for Research, Rolin F. Barrett, Assistant Dean.

113-08198-400-44

DYNAMICS OF FLOW IN ESTUARINE WATERS

(*b*) Sea Grant.
(*c*) Dr. Michael Amein, Dept. of Civil Engineering, and Dr. Charles E. Knowles, Dept. of Geosciences.
(*d*) Theoretical and field.
(*e*) Development and application of numerical hydrodynamic models for the study of flow dynamics in North Carolina estuaries. An explicit two-dimensional model is used to study circulation and wind tides in Pamlico Sound and an implicit four-point model is used to study the dynamics of flow through inlets and river estuaries. The results of computations are tested with field observations.
(*g*) A model for Masonboro Inlet system has been completed. Comparison of observed and computed results indicate that the numerical model can successfully predict flow dynamics in inlets of great complexity. The two-dimensional model provides useful estimates of water levels and currents in large shallow water bodies such as Pamlico Sound.
(*h*) **Computation of Flow Through Masonboro Inlet,** M. Amein, *J. Waterways, Harbors and Coastal Engrg., ASCE* **101,** Feb. 1975.

113-08882-450-75

EXPERIMENTS RELATED TO OCEAN SURFACE DYNAMICS

(*b*) Applied Science Associates, Inc.
(*c*) Dr. Furman Y. Sorrell, Engineering Science and Mechanics.
(*d*) Experimental.
(*e*) Conduct experiments relating to the interactions between capillary waves and currents under laboratory conditions.
(*g*) A new instrument for measuring ocean surface roughness has been developed, and it demonstrates that previous measurements have been in error in some conditions.
(*h*) **An Alternate to Hot Film Flow Sensors,** F. Y. Sorrell, G. V. Sturm, *Rev. Sci. Instrum.* **45,** 2, p. 300, Feb. 1974.
Optical Wave Measurement Technique and Experimental Comparison With Conventional Wave Height Probes, G. V. Sturm, F. Y. Sorrell, *Appl. Optics* **12,** 8, p. 1428, Aug. 1973.
Cross Waves on Longitudinal Capillary Waves With Mean Water Currents, G. V. Sturm, F. Y. Sorrell, *Bull. Amer. Phys. Soc.* **18,** p. 1486, 1973.

113-08883-540-14

TRANSONIC VISCOUS INTERACTIONS

(*b*) U. S. Army Research Office – Durham.
(*c*) Dr. Frederick O. Smetana, Mechanical and Aerospace Engineering.
(*d*) Theoretical and experimental.
(*e*) Study the characteristics of supercritical airfoils derived by considering longitudinal viscous effects in the free stream flow at transonic speeds.
(*f*) Completed.
(*g*) Small amount of success has resulted from trying to develop semi-empirical techniques to predict reactions by a body.
(*h*) **Toward Simpler Prediction of Transonic, Airfoil, Lift, Drag and Movement,** F. O. Smetana, *J. Aircraft* **10,** 2, pp. 124-126, Feb. 1973.

113-08884-420-88

OCEAN DYNAMICS SURFACE CURRENTS

(*b*) Research Triangle Institute.
(*c*) Dr. Norden E. Huang, Dept. of Geosciences.
(*d*) Theoretical, experimental and field.
(*e*) Determine the feasibility of measuring ocean surface currents from satellite and aircraft. Project consists of theoretical analysis, laboratory experiments and actual sea measurements.
(*f*) Complete.
(*g*) Interactions between steady non-uniform currents and gravity waves are generalized to include the case of a random gravity wave field.
(*h*) **Interactions Between Steady Non-Uniform Currents and Gravity Waves With Applications For Current Measurements,** N. E. Huang, D. T. Chen, C. C. Tung, J. R. Smith, *J. Phys. Oceanog.* **2,** 4, pp. 420-431, Oct. 1972.

113-08885-140-54

FREEZING OF LIQUIDS IN INTERNAL AXISYMMETRIC TURBULENT AND LAMINARIZING FLOW

(*b*) National Science Foundation.
(*c*) Dr. James C. Mulligan, Mechanical and Aerospace Engineering.
(*d*) Theoretical and experimental.
(*e*) The internal axisymmetric free-boundary problem of freezing in a cooled horizontal tube of circular cross-section will be investigated both analytically and experimentally for the case of turbulent flow.
(*g*) The heat transfer and pressure drop characteristics of tubes which are freezing internally in laminar flow have been described analytically as well as experimentally. Presently working on the same kinds of problems for turbulent flow in tubes.

113-08886-410-44

A NEW METHOD OF BEACH STABILITY CONTROL

(*b*) Sea Grant.
(*c*) N. E. Huang, Dept. of Geosciences, and J. L. Machemehl, Dept. of Civil Engineering.
(*d*) Theoretical, experimental and field.
(*e*) Explore the feasibility of beach stabilization and control by artificially changing the flow condition near the bottom through pumping (suction) on the beach.
(*f*) Completed.
(*g*) A study of a sub-sand filtering system was conducted to determine the effectiveness of the system in stabilizing the off-shore profile, to determine the effectiveness of the system on stabilizing the foreshore profile and speeding accretion on the foreshore during periods of natural accretion, and to determine the effectiveness of the system in decreasing breaking scour. In the off-shore zone, the filters had a stabilizing effect on the material directly above them; in the breaker zone, the filters had little effect on breaker scour except on the smallest waves in the study; and in the foreshore zone, the filters were a tremendous aid in speeding accretion. The filter system generated rapid and large accretion on the foreshore. The filter system was found very effective in replacing a depleted berm.
(*h*) **A New Technique for Beach Erosion Control,** T. French, N. E. Huang, J. L. Machemehl, *Center of Marine and Coastal Studies, N. C. State Univ., No. 74-3,* July 1974; also presented at Ocean Engrg. Conf., Univ. of Delaware, June 1975.

UNIVERSITY OF NORTH CAROLINA — CHAPEL HILL, School of Public Health, Department of Environmental Sciences and Engineering, Chapel Hill, N. C. 27514. Dr. Russell F. Christman, Department Chairman.

114-0378W-860-33

WATER DEMAND FORECASTING FOR THE STATE LEVEL

(*c*) Dr. Donald T. Lauria.
(*e*) See WRRC **8,** 6.0975.

114-09639-870-60

THERMAL MODELING OF HYCO RESERVOIR

(*b*) N. C. Department of Natural and Economic Resources.
(*c*) Drs. Donald E. Francisco and Donald T. Lauria.
(*d*) Field investigation for applied research.
(*e*) Development of predictive non-steady state finite difference temperature models for Hyco Reservoir, a cooling lake for an electric generating plant in North Carolina.
(*g*) The results consist of a computer program for predicting temperatures in Hyco Reservoir based on heated water discharges, solar radiation, evaporation and additional phenomena responsible for heat flux in natural systems.

114-09640-860-00

STRATEGY FOR RIVER QUALITY MANAGEMENT

(*c*) Dr. Donald T. Lauria.
(*d*) Theoretical applied research.
(*e*) Investigation of alternative schemes for the optimal allocation of dissolved oxygen resources among polluters of Haw River, N. C. An existing predictive quality model for the river is incorporated into a linear programming model to determine least cost waste treatment requirements and an optimal set of effluent charges for pollution.

114-09641-870-54

REGIONAL SEWERAGE PLANNING BY MIXED INTEGER PROGRAMMING

(*b*) National Science Foundation.
(*c*) Dr. Donald T. Lauria.
(*d*) Theoretical applied research for Master's thesis.

(e) Development of a mixed integer programming model for determining the optimal location, timing and scale of regional wastewater facilities including treatment plants and sewers. Application to a region with 18 alternative plant sites; solution using IBM's MPSX-MIP algorithm for the 370/165 computer employing such heuristic techniques as disaggregation, upper bounding, priority ordering, time staging, and search interruption.
(f) Completed.
(g) Nine mixed integer programming problems were solved with from 20 to 200 integer variables, 40 to 250 continuous variables, and 60 to 450 constraints. The longest computer time for a problem was about 11 minutes. Time staging provided fast results and required minimum user input and expertise. It was concluded that treatment process selection cannot be incorporated as a decision variable in this model for realistically sized problems.

114-09642-860-61

STRATEGIES FOR WATER QUALITY MONITORING

(b) N. C. Water Resource Research Institute.
(c) Drs. David H. Moreau and Jabbar K. Sherwani.
(d) Theoretical applied research for Master's thesis.
(e) Development of strategies for the location, density, frequency and duration of water quality samples in a multi-purpose water quality monitoring system for state agencies concerned with planning, management, enforcement and research.
(f) Completed.
(g) Critical conditions in a natural aquatic system depend on the severity, duration and frequency of departure of the quality factor of interest from a reference standard. In North Carolina, critical oxygen conditions do not necessarily occur at low flows. The design of a monitoring network might be based on an "impact index" which takes account of the probability of violation of standards, the number of affected users, size of the stream, its existing and planned use, and its natural quality. The basic elements in developing a strategy for monitoring include (1) a baseline study to identify quality problems, (2) intensive sampling of stations near critical points, and (3) extensive less-frequent sampling of stations throughout the study region.

114-09643-820-61

PUBLIC POLICY FOR THE MANAGEMENT OF GROUNDWATER RESOURCES IN THE COASTAL PLAIN OF NORTH CAROLINA

(b) N. C. Water Resources Research Institute.
(c) Dr. Jabbar K. Sherwani.
(d) Theoretical applied research.
(e) Evaluation of alternative patterns of withdrawals in the piezometric surface. Assessment of the potential of water quality deterioration and the relative importance of the possible causes. Identification of the areas suitable for recharge and their capabilities. Estimation of benefits and costs of groundwater in its several uses and subsidies in guiding groundwater development.

114-09644-820-60

GROUNDWATER QUALITY MODELS AND SOLUTION TECHNIQUES FOR THE CASTLE-HAYNE AQUIFER SYSTEM

(b) N. C. Board of Science and Technology.
(c) Dr. Jabbar K. Sherwani.
(d) Theoretical basic research.
(e) Formulation and solution of mathematical models for alternative mechanisms which cause deterioration of groundwater quality.

114-09645-860-33

EFFECTS OF CHANNELIZATION ON WATER QUALITY OF FLOOD PLAIN SWAMPS IN EASTERN NORTH CAROLINA

(b) Office of Water Resources Research and N. C. Water Resources Research Institute.
(c) Dr. Edward J. Kuenzler.
(d) Experimental applied research for Doctoral dissertation.
(e) The goal is to understand how swamps affect water quality and how these effects may be changed by channelization. The specific objective is to determine throughout the year the changes in the forms and concentrations of certain plant nutrients and organic substances in a stream as it passes through a flood-plain swamp. Three swamps in North Carolinaare being studied, one not scheduled for channelization, one scheduled for channelization, and one channelized about 7 years ago.

NORTH DAKOTA STATE UNIVERSITY OF AGRICULTURE AND APPLIED SCIENCE, Agricultural Engineering Department, Fargo, N. Dak. 58102. Professor Earl C. Stegman.

115-09018-840-00

UNDERGROUND PIPE EVALUATION FOR IRRIGATION SYSTEMS

(c) H. M. Olson, Carrington Irrigation Branch Station.
(e) Approximately 15,000 feet of PVC, asbestos-cement, concrete and vinyl-clad aluminum irrigation pipe have been buried within the soil frost zone with thirty to thirty-six inches of soil cover on the Carrington Irrigation Station at Carrington, North Dakota. All pipe lines have been laid to grade to permit drainage of water before freeze-up. The pipe line distribution system has been in use for periods ranging from four to ten years. During this time various studies have been conducted to evaluate the performance of the various pipe materials under the normal field conditions in this area. Vertical control was established and monitored periodically to identify any changes in elevation that may result from freezing and thawing of the soil profile. Control points were established on both the top and bottom of the thin walled PVC pipe to measure deflection as related to method of backfill and imposed surface loads. An artificial high water table was established in an attempt to achieve maximum frost action and measure its effect on low head PVC pipe. Head loss measurements were made in several sections of pipe first in 1969 shortly after installation, and again after five years of use to identify any changes that may have taken place to alter the capacity of the pipe lines. They were determined to be minor.
(g) Results of the studies and observations suggest that relatively shallow placement of pipe lines within the soil frost zone have identified no new or different problems than those encountered in areas of milder temperatures where similar installations have been in operation for many years. The one precaution that must be taken is that pipelines must be laid to grade so drainage of water from the pipe can be accomplished before winter freeze-up.
(h) **Performance of Irrigation Pipe Lines Buried Within the Frost Zone,** H. M. Olson, L. A. Busch, E. R. Miller, *ASAE Paper No. 74-2531*, Winter Mtg., Chicago, Dec. 10-13, 1974.

115-09019-860-00

EVALUATION OF NORTH DAKOTA'S FIRST RURAL WATER SYSTEM

(e) One hundred and twenty-five members of the Grand Forks-Traill Water Users Association, and 40 non-members residing within the same area were interviewed in June 1974. Information obtained isbeing compared with data collected in 1972 from the same respondents to determine changes which have occurred during the first

two years of the water system's operation. Multiple regression analysis is being employed to identify the direct effect of membership on selected expenditures. The direct economic impact will be used as an estimate of change in final demand in the North Dakota regional input-output model to determine the total economic impact in the area.

(*g*) Data on the delivery of water to six farms on Grand Forks-Traill water system have been completed. Recording of water demands on a five- or ten-minute interval has been obtained from family units as follows: House in town – 1; Farms without livestock – 3; Farms with livestock – 2. Data were collected for a five-day period on each of the units. It is expected to show five-minute demands during a 16-hour period from 6:00 A.M. to 10:00 P.M. Ten-minute demands were recorded from 10:00 P.M. to 6:00 A.M. Information available will be total daily consumption, maximum five-minute demand during a 24-hour period, and its time of occurrence, hourly demands, and variation of demands.

Chemical and bacteriological analyses of the wells serving the Grand Forks-Traill water systems were made. The system went into operation in January 1973, and chlorination of the water system was discontinued during the Spring of 1973. The reason given for discontinuing chlorination was to prevent precipitation of the iron content throughout the water supply. In 1972, a questionnaire was administered and the data provided information such as ownership of water using appliances, amount of water consumed, uses of water, value of homes, etc. A follow-up questionnaire was administered in 1974 to provide comparison data. Comparisons will be drawn between members and non-members to determine the impact of a readily available source of water.

(*h*) **The Evaluation of Water Quality in the Grand Forks-Traill Water System,** S. A. Rice, *Master's Thesis in Textiles in Clothing of Home Economics*, available N. Dak. State Univ. Library.

NORTHWESTERN UNIVERSITY, The Technological Institute,

Evanston, Ill. 60201. Dr. Bruno Boley, Dean.

116-03799-030-00

FORCES ON SUBMERGED BODIES IN UNSTEADY MOTION

(*c*) Professor W. S. Hamilton, L. F. Mockros, Dept. of Civil Engineering.

(*d*) Theoretical and experimental; basic research; M.S. and Ph.D. theses.

(*e*) Investigation of the forces on solid bodies accelerating along a rectilinear path through incompressible viscous fluids. The investigation includes experiments that will be compared with numerical evaluation of theoretical linear solutions; experiments on the general case of large motions; and a study of the effect of the velocity pattern on added mass.

(*g*) The drag on accelerating spheroids has been calculated from linearized theory. Added mass coefficients for spheres moving away from a plane boundary and parallel to a constant pressure surface have been calculated from potential theory. Experiments involving spheres near a plane boundary and accelerating after a period of constant velocity are complete. Applications to wave forces on piles and viscous drag at the beginning of motion are under study.

(*h*) **The Stokes-Flow Drag on Prolate and Oblate Spheroids During Axial Translatory Accelerations,** R. Y. S. Lai, L. F. Mockros, *J. Fluid Mech.* **52**, pp. 1-15, 1972.

Fluid Force Analysis and Accelerating Sphere Tests, W. S. Hamilton, J. E. Lindell, *J. Hydraul. Div., Proc. ASCE* **97**, pp. 805-817, June 1971.

Fluid Force on Accelerating Bodies, W. S. Hamilton, *Proc. 13th Coastal Engrg. Conf., ASCE*, Vancouver, Canada, pp. 1767-1782, July 1972.

116-05472-440-00

DYNAMICS OF THE CIRCULATION IN THE GREAT LAKES

(*c*) Professor G. E. Birchfield.

(*d*) Theoretical study; primarily basic research.

(*e*) Develop mathematical models of wind generated motions in large lakes. Use with recent observational studies to construct model of general circulation.

(*h*) **Theoretical Aspects of Wind-Driven Currents in a Sea or Lake of Variable Depth with No Horizontal Mixing,** G. E. Birchfield, *J. Phys. Oceanog.* **2**, 4, pp. 355-362, 1972.

An Ekman Model of Coastal Currents in a Lake or Shallow Sea, G. E. Birchfield, *J. Phys. Oceanog.* **3**, pp. 419-428, 1973.

A Numerical Model for Wind-Driven Circulation in Lakes Michigan and Huron, G. E. Birchfield, T. S. Murty, *Mon. Weather Rev.* **102**, 2, pp. 157-165, 1974.

116-05474-270-40

EXTRACORPOREAL CIRCULATION

(*b*) National Heart and Lung Institute.

(*c*) Professor Lyle F. Mockros.

(*d*) Theoretical and experimental; basic and applied research; M.S. thesis; Ph.D. dissertation.

(*e*) Investigation of the geometry and fluid dynamics favorable to the circulation of blood outside the animal body. Purpose is to obtain design criteria for heart-lung machines.

(*g*) Oxygen and carbon dioxide transfer to and from blood, respectively, is being investigated theoretically and experimentally. Investigations include studies of steady and unsteady laminar convection in various flow geometries, and relationships between flow mechanics and thrombogenesis.

(*h*) **Design Limitations of Membrane Oxygenators,** J. D. S. Gaylor, L. F. Mockros, *Proc. 25th Ann. Conf. on Engrg. in Medicine and Biology* **14**, p. 3.1, 1972.

Viscoelastic Properties of Fibrin Clots, W. W. Roberts, L. Lorand, L. F. Mockros, *Biorheology* **10**, pp. 29-42, 1973.

Gas Transfer and Thrombogenesis In An Annular Membrane Oxygenator With Active Blood Mixing, J. D. S. Gaylor, J. F. Murphy, J. A. Caprini, L. Zuckerman, L. F. Mockros, *Trans. Amer. Soc. for Artificial Internal Organs* **19**, pp. 519-524, 1973.

Viscoelastic Properties of Ligation-Inhibited Fibrin Clots, L. F. Mockros, W. W. Roberts, L. Lorand, *Biophys. Chem.* **2**, pp. 164-169, 1974.

Contact Activation of Heparinized Plasma, A. Caprini, J. B. Eckenhoff, J. M. Ramstack, L. Zuckerman, L. F. Mockros, *Thrombosis Res.* **5**, pp. 379-400, 1974.

116-07537-190-20

EFFECTS OF THERMAL CONVECTION CURRENTS ON FORMATION OF ICE IN SEA WATER

(*b*) Office of Naval Research.

(*c*) R. S. Tankin.

(*d*) Primarily experimental.

(*e*) A Mach Zehnder interferometer is used to study the interaction between convection currents in sea water and the ice-water interface during freezing. The temperature at the ice-water interface during early stages of freezing is approximately 0 °C – not the equilibrium freezing temperature. Salt fingers were observed to first appear from specific sites in the ice-water interface. The salinity profiles in the salt fingers were measured using interferograms in conjunction with Abel inversion. The maximum salinity along the center line of the salt-finger is an indication of the salinity of the brine trapped within the ice.

(*f*) Completed this phase of the study.

(*h*) A paper entitled **Interferometric Study of Two-Dimensional Benard Convection Cells** is to appear in *J. Fluid Mechanics.*

116-08209-270-40

PRESSURE AND FLOW IN THE SYSTEMIC ARTERIAL SYSTEM

(*b*) National Institute of General Medical Sciences.
(*c*) Professor Lyle F. Mockros.
(*d*) Theoretical and experimental; basic and applied research; Ph.D. dissertation.
(*e*) The central and peripheral arterial system are mathematically modeled. The method of characteristics is used to study the properties of physiologic and pathologic arterial systems. The purpose is to investigate the effectiveness of various diagnostic, therapeutic techniques.
(*g*) Calculations indicate that reflections are the major factor determining the shape and distal amplification of the pressure wave in the arterial tree; although important in attenuating the proximal transmission of reflecting waves, geometric taper is not the major cause of the distal pressure wave amplification; elastic taper and nonlinearity of the wall elasticity are of minor significance in determining the flow and pressure profiles.
(*h*) **Pressure and Flow in the Systemic Arterial System,** R. R. Wemple, L. F. Mockros, *J. Biomechanics* **5**, pp. 629-641, 1972.
An Analysis of Mechanical Cardiac Assistance, R. R. Wemple, L. F. Mockros, *J. Biomechanics* 6, pp. 99-108, 1973.

116-08210-270-40

FLUID DYNAMICS IN THE UPPER PULMONARY AIRWAYS

(*b*) National Institute of General Medical Sciences.
(*c*) Professor L. F. Mockros.
(*d*) Theoretical and experimental; basic and applied research; Ph.D. dissertation.
(*e*) Fluid dynamical details in the bifurcating manifolds of the upper airways is being investigated experimentally and analytically. Hot-wire measurements are made in plastic models and in rubber reproductions derived from airway casts. The casts also are used to determine airway geometry. Numerical solutions of the Navier-Stokes equations are used to study the flow behavior through a bifurcating channel.
(*g*) Separation does not appear to be common in the lungs, in spite of the many junctions. Transition sections seem to smooth the flow. The major head losses occur at the junctions, however.

116-08887-090-52

LIQUID-LIQUID SURFACE IMPACTION

(*b*) Energy Research and Development Administration.
(*c*) Professor S. G. Bankoff.
(*d*) Theoretical and experimental; basic and applied research; Ph.D. dissertation.
(*e*) Drops .2-2 mm are allowed to fall from heights of 0-20 cm on the surface of a liquid pool whose temperature ranges from ambient to well above the homogeneous nucleation temperature of the drop liquid. Critical conditions for rebound without coalescence will be determined for several liquid combinations. The drainage of a gas film between the drop and pool liquid will be studied theoretically, taking into account surface evaporation and adsorption.
(*f*) Experimental equipment being assembled.

116-08888-340-52

MODELING OF CLADDING AND FUEL MOTION IN A LOSS-OF-FLOW SITUATION FOR GAS COOLED FAST REACTOR SAFETY ANALYSIS

(*b*) Energy Research and Development Administration.
(*c*) Donald T. Eggen, Professor Nuclear Engineering.
(*d*) Develop models for safety analysis of gas-cooled fast reactors; experimental and numerical.
(*e*) Program includes both experiments and the development of analytical computer models of cladding and fuel motion under GCFR loss-of-flow conditions. Three series of scoping experiments of increasing complexity will be performed on the motion, freeze-out, and coolant channel plugging of molten cladding. Computer models of these and related phenomenon are to be developed.
(*f*) First experiments on crude models have been done.
(*g*) Liquid p_b/s_n alloy-simulating stainless cladding – partially flowed through "lower blanket" and partly froze (about 40 flowed through, 60 percent frozen).

116-08889-100-34

ROD-IN-FREE-SURFACE MENISCAL BREAKOFF METHOD FOR MEASUREMENT OF VERY SMALL INTERFACIAL TENSION

(*b*) U. S. Department of the Interior, Bureau of Mines.
(*c*) Professor A. A. Kovitz, Dept. of Mechanical Engrg. and Astronautical Sciences; Professor S. C. Slattery, Dept. of Chemical Engrg. (co-principal investigator).
(*d*) To employ the meniscal breakoff height as a measure of the interfacial tension between brine-surfactant-crude oil systems.
(*e*) The meniscus external to a circular rod displays a family of static shapes. For a given rod radius there is a maximum height above the general level of the interface at which the meniscus has no static shape; this break-off height is related to the rod radius, density difference between the two fluids, and interfacial tension. It is this break-off height which will be used to measure the interfacial tension.
(*f*) Preliminary experiments on water-air systems have been completed. Construction of the apparatus for the brine-surfactant-crude oil system is being initiated.
(*g*) Experiment and theory for the water-air system are in good agreement. The theoretical results include numerical and analytical conclusions.
(*h*) **Static Fluid Interfaces External to a Right Circular Cylinder – Experiment and Theory,** A. A. Kovitz, *J. Coll. Interface Sci.*, 1975.

116-08890-090-00

A STUDY OF PENDANT DROPS – THEORY AND EXPERIMENT

(*c*) Professor A. A. Kovitz, Dept. of Mechanical Engrg. and Astronautical Sciences.
(*d*) To study the shapes and limiting conditions for the existence of static pendant drops.
(*e*) Pendant drops were observed for known contact circle radii and contact circle pressure. Observations were compared with theory (solutions of the Young-Laplace equations).
(*f*) Results for water-air systems are complete; further work using surfactants and rotating drops is contemplated.
(*g*) Theory yields high and low pressure limits for static drops. Experiments are in good agreement with theory, including the existence of multiple solutions for a fixed contact circle radius and pressure.
(*h*) **The Pendant Drop: Theory and Experiment,** A. A. Kovitz, *Proc. Intl. Colloq. on Drops and Bubbles*, Pasadena, Calif., Aug. 28-30, 1974.

UNIVERSITY OF NOTRE DAME, Department of Aerospace and Mechanical Engineering, Notre Dame, Ind. 46556. Professor K. T. Yang, Department Chairman.

117-07542-720-36

THE SIMULATION OF THE ATMOSPHERIC SURFACE LAYER IN THE NOTRE DAME ATMOSPHERIC WIND TUNNEL

(*b*) National Science Foundation, Environmental Protection Agency.
(*c*) Professors V. W. Nee, A. A. Szewczyk, K. T. Yang, R. Betchov.
(*d*) Experimental, basic research.

(*e*) At Notre Dame, a 5 ft x 5 ft x 65 ft atmospheric wind tunnel has been designed and constructed with a unique feature of incorporating a volumetric turbulence generation box. It is capable of generating strong turbulence as well as providing a flexible and effective means of separately controlling the turbulence characteristics with many adjustable side jets. Results obtained so far indicate that a very thick boundary layer with a logarithmic profile of the order of one meter high can be established simultaneously with constant high intensity and Reynolds stress distributions. The energy decay downstream is surprisingly small. Current measurements include turbulence power spectra by hot wires and signals are monitored and analyzed directly through an automated data acquisition system utilizing a mini-computer.

(*h*) **The Simulation of the Atmospheric Surface Layer With Volumetric Flow Control,** V. W. Nee, C. Dietrick, A. A. Szewczyk, R. Betchov, *Proc. 19th Inst. Environ. Sci.*, Apr. 1973.
The Simulation of the Atmospheric Surface Layer in the Notre Dame Atmospheric Wind Tunnel, V. W. Nee, A. A. Szewczyk, K. T. Yang, *Proc. 1974 Air Pollution Control Assoc. Ann. Mtg.*, June 1974.

117-07543-000-00

NUMERICAL SOLUTIONS OF A VISCOUS FLOW PAST A CIRCULAR CYLINDER WITH STREAM-WISE VELOCITY FLUCTUATIONS

(*c*) Assoc. Professor V. P. Goddard, Professor A. A. Szewczyk.
(*d*) Theoretical basic research.
(*e*) Numerical solutions of the incompressible, two-dimensional, time dependent Navier-Stokes equations have been obtained for the flow past a circular cylinder with free-stream velocity fluctuations in the flow direction. The fluctuations in the flow are produced by a change in magnitude only and not in direction. The resulting time dependent equations are solved by the use of an explicit-finite difference scheme possessing conservative and transportive properties for a stream-function-vorticity formulation. Results are available for Reynolds number 40 and 200, and non-dimensional free-stream frequencies of 0.02 to 3.2.
(*h*) **Numerical Solutions of the Viscous Flow Past a Circular Cylinder With Stream-Wise Velocity Fluctuations,** V. P. Goddard, A. A. Szewczyk, *Proc. XIth Biennial Fluid Dyn. Symp.*, Polish Acad. Sci., 1973.

117-07546-550-20

STUDIES RELATED TO UNDERSEA JET PROPULSION

(*b*) Office of Naval Research.
(*c*) Professor K. T. Yang.
(*d*) Experimental, basic research.
(*e*) Study concerned with the experimental investigation of the velocity, temperature and pressure fields surrounding a supersonic steam jet discharging into a channel with slowly moving water flow. Six different flow regions have been identified as a function of the axial pressure ratio across the jet, each giving rise to distinct jet bubble shapes and noise emissions characteristics. Detailed analysis based on high-speed photography is now under way.
(*h*) **Vapor-Liquid Interaction in a High Velocity Vapor Jet Condensing in a Coaxial Water Flow,** R. J. Young, K. T. Yang, J. L. Novotny, *Proc. 5th Intl. Heat Transfer Conf.* **III**, pp. 226-230, 1974.

117-07548-550-20

FLOW FIELD CHARACTERISTICS OF AXISYMMETRIC AND NON-AXISYMMETRIC ALTITUDE COMPENSATING PROPULSIVE NOZZLES

(*b*) NASA.
(*c*) Professor T. J. Mueller.
(*d*) Theoretical and experimental, basic research.
(*e*) Analytical and experimental descriptions of the flow field and base pressure characteristics have been obtained for axisymmetric and non-axisymmetric truncated plug nozzles. The process of wake closure, Mach disc formation, and the effects of base bleed have been studied.
(*h*) **Annular Truncated Plug Nozzle Flow Field and Base Pressure Characteristics,** W. P. Sule, T. J. Mueller, *AIAA J. Spacecraft and Rockets* **10,** 11, pp. 689-695, 1973.

117-08891-020-54

TURBULENCE MEASUREMENTS AND MODELING

(*b*) National Science Foundation.
(*c*) Professor R. Betchov.
(*d*) Theoretical and experimental, basic research.
(*e*) The process of fluid deformation and vorticity concentration in turbulent flows is studied. It is found that the stretching of the vorticity is always associated with collision between advancing fluid masses. This produces thin regions, where most of the energy dissipation occurs. Numerical models for three-dimensional time dependent flows give results which confirm data from hot-wire studies, and provide insight on the rate of deformation tensor in turbulent flow.

117-08892-020-00

NUMERICAL SIMULATION OF ISOTROPIC TURBULENCE WITH VISCOSITY

(*c*) Professors R. Betchov and A. A. Szewczyk.
(*d*) Theoretical, basic research.
(*e*) The equations of Navier-Stokes are integrated numerically for isotropic box turbulence. Initially the Box of $(57)^3$ lattice points is filled with a Gaussian velocity field obtained by a linear diffusion process. The equations in real space are finite differenced and numerically integrated in time with a constant value of the viscosity. Various order correlations and the associated skewness as a function of time and separation distance approaches a constant value as $t \rightarrow \infty$.The correlations of order five to eight exhibit the high spikes characteristically found in experiments. Calculations without viscosity (Euler equations) give similar results, with stronger spikes in the high correlations. In some cases, the relation between the rate of deformation tensor and the vorticity vector have been studied.

117-08893-000-54

NUMERICAL AND PHYSICAL EXPERIMENTS IN VISCOUS SEPARATED FLOWS

(*b*) National Science Foundation.
(*c*) Professor T. J. Mueller.
(*d*) Theoretical, basic research.
(*e*) Compare the results of finite difference solutions to the Navier-Stokes equations with the results of appropriately designed physical experiments. The separated flow studied includes those incompressible planar flows produced by the blunt base, front step, back step, and cavity flows as well as the more complicated axisymmetric flow through a fully open disc type prosthetic heart valve.

117-08894-000-26

LAMINAR AND TURBULENT AERODYNAMIC EFFECTS OF STEADY AND UNSTEADY DIFFUSION ABOUT WING SURFACES

(*b*) Air Force Office of Scientific Research.
(*c*) Professor V. W. Nee.
(*d*) Theoretical, basic research.
(*e*) The diffusion of vorticity in an unsteady laminar flow is investigated with a novel approach by the study of a vanishing plate in a uniform flow. The analysis is made with the employment of both perturbation method and the successive approximation method. Results obtained compared favorably with the computer solution. Turbulent shear flow with heat transfer is investigated here with the establishment of rate equations governing the Reynolds stresses and the velocity-temperature correlation function. Preliminary results obtained have been favorably compared with experimental data.

(*h*) **The Sudden Melting of a Thin Plate in a Forced Convection Flow,** V. W. Nee, F. B. Cheung, Y. L. Chen, *Proc. 5th Intl. Heat Transfer Conf.*, No. FC 2.4, pp. II 65-69, 1974.

17-08895-630-26

NSTEADY AERODYNAMIC FORCES ON CAMBERED AIRFOILS

(*b*) Air Force Office of Scientific Research.
(*c*) Assoc. Professor H. Atassi.
(*d*) Theoretical, basic research.
(*e*) Unsteady flows in turbomachines produce fluctuating pressure distribution and lift forces on blades of rotor and stator. The present study develops an analytical approach to determine the effects of angle of attack, camber, and thickness on the unsteady pressure and aerodynamic forces acting on such blades. The effects of the fluctuating pressure on the boundary layer along the blades and the conditions under which a dynamic stall is induced are also investigated.

17-08896-630-50

NFLUENCE OF BLADE LOADING ON THE ACOUSTIC RESPONSE OF A CASCADE

(*b*) NASA Lewis Research Center.
(*c*) Assoc. Professor H. Atassi.
(*d*) Theoretical, basic research.
(*e*) The unsteady lift forces acting upon cascade blades in a nonuniform flow are investigated. The study accounts for the effects of the different parameter of the cascade, namely, the aerodynamic load, angle of attack, camber and thickness of cascade blades, cascade solidity, stagger angle, and deviation angle. The results will be applied to calculating the dipole noise field as well as the quadruple originated noise. Optimization and sensitivity studies will equally be carried out so as to determine the optimal parameters of the cascade yielding minimum fluctuating lift for a given aerodynamic performance.

17-08897-030-54

EFFECTS OF TURBULENCE AND SHEAR ON FLOW PAST BLUFF BODIES

(*b*) National Science Foundation.
(*c*) Professor A. A. Szewczyk.
(*e*) Determine the effect of shear on the flow past finite bluff bodies. It is envisioned that the initial investigation will take place with a tailored linear velocity profile with low turbulence. In later studies the effect of turbulence superimposed on the shear flow will be studied past the same bluff bodies used in the initial experiments. The following sets of experiments will be carried out: 1) investigation of shear flow with low intensity turbulence, 2) investigation of a shear flow with medium intensity turbulence, and 3) investigation of a shear flow with high intensity turbulence.

117-08898-030-00

NTERFERENCE EFFECTS DUE TO TWO IN-ROW CYLINDERS

(*c*) Professor A. A. Szewczyk.
(*d*) Experimental, basic research.
(*e*) The interference effects due to two in-row cylinders are studied by making pressure and velocity measurements. The effects are parameterized by the gap spacing between the two cylinders. At present steady flow and average pressure measurements are being investigated. It is planned to measure the pressure fluctuations in the wake via flush mounted transducers at sub-critical Reynolds numbers.

117-08899-550-00

A DIRECT METHOD FOR CALCULATING THE TRANSONIC REGION IN PROPULSIVE NOZZLES

(*c*) Professor T. J. Mueller.
(*d*) Theoretical, basic research.
(*e*) The basis of this potential flow method is a reformulation of the normally mixed type of problem in terms of an elliptic problem. This simplification is brought about by expressing the nonlinear compressibility terms as a function of the spatial coordinates. The reformulation introduces the necessity of specifying a boundary condition on the outflow boundary and uncovers an auxiliary condition.

117-08900-870-36

MATHEMATICAL MODELING OF ATMOSPHERIC DISPERSION OF POLLUTANTS IN SURFACE LAYERS

(*b*) Environmental Protection Agency.
(*c*) Professors V. W. Nee and K. T. Yang.
(*d*) Theoretical, basic research.
(*e*) A phenomenological differential field theory has been developed to predict the dispersion of pollutants in the atmospheric surface layer downwind of emission sources. A salient feature of this theory is the use of a turbulence rate equation taking into account various mechanisms of turbulence convection, diffusion, generation and decay. Calculations have been made for line and point sources on the ground under both neutral and stratification conditions and results compare very favorably with wind tunnel test data. Currently, the theory is being extended to elevate sources with surface roughness distribution.
(*h*) **Mass Diffusion From a Line Source in a Neutral Turbulent Shear Layer,** S. Rao, V. W. Nee, K. T. Yang, *Proc. 1972 Heat Transfer and Fluid Mech. Inst.*, pp. 182-199, 1972.
Diffusion in a Thermally Stratified Turbulent Boundary Layer, S. Rao, V. W. Nee, K. T. Yang, *Proc. 5th Intl. Heat Transfer Conf.* V, pp. 34-38, 1974.

117-08901-870-70

PRESSURE DROP IN FABRIC FILTRATION

(*b*) Dustex, Division of American Precision Industries.
(*c*) Assoc. Professor T. Ariman.
(*d*) Theoretical and experimental, applied research.
(*e*) An analytical and experimental research program has been underway to develop a semi-empirical model for the determination of the pressure drop during the filtration process of dust laden gases. Particle size and size distribution, particle shape, gravity, dust cake thickness, gaseous properties, such as viscosity and density, filtering velocity, relative humidity, temperature, cleaning mechanism and fabric structure have been incorporated into the proposed pressure-drop model. An experimental program based on a bench scale filter system and a dust bag simulator has been underway for the correlation of the pressure drop formulation.
(*h*) **On Collection of Dust by Fabric Filters in an Electrostatic Field,** T. Ariman, K. S. Rao, K. T. Yang, *Proc. 2nd Ann. Environ. Engrg. and Sci. Conf.*, pp. 555-571, 1973.

117-08902-270-54

TRANSPORT PHENOMENA RELATED TO PROSTHETIC HEART VALVE THROMBUS FORMATION AND ERYTHROCYTE DAMAGE

(*b*) National Science Foundation.
(*c*) Professor T. J. Mueller and Assoc. Professor J. R. Lloyd.
(*d*) Experimental; applied and basic research.
(*e*) Development of in vitro experimental apparatus and diagnostic techniques which can be used to evaluate any existing prosthetic heart valve or future valve design. This will aid in designing future valves which exhibit less hemolytic and thrombogenic potential. The characteristic local mass and momentum transfer associated with the flow through prosthetic heart valves will be determined for two valves; the caged ball and the caged disc. The local mass transfer data will quantitatively indicate the character of the flow-induced thrombogenic regions while the local momentum transfer data will locate high shear regions where erythrocytes may be lysed or severely strained. The flow through an empty aortic chamber, the aortic chamber with sewing ring only, and the aortic chamber with the complete heart valve are studies under both steady and pulsatile flow con-

ditions in a mock mirculatory system. Electrochemical techniques are used in the mass transfer experiments, and hot film anemometry in the momentum transfer experiments. In vitro experiments with blood will be performed in the mock circulatory system in order to determine the occurrence and severity of erythrocyte damage and thrombus formation and their relationship to the data obtained by the mass and momentum transfer experiments.

117-08903-270-00

MICROCONTINUUM RHEOLOGY OF BLOOD

(*c*) Assoc. Professor T. Ariman.
(*d*) Theoretical, basic research.
(*e*) The steady and pulsatile flow of blood through small, rigid circular tubes has been analyzed by a microcontinuum approach. A new boundary condition on red blood cell rotations at solid boundaries is used. The steady pulsatile solution for velocity and cell-rotational velocity are obtained through application of consecutive Hankel and Laplace transforms. The rotational viscosity and rotational gradient coefficients are determined as a function of hematocrit from the experimental in vitro blood flow data. A comparison of the theoretical velocity profiles with the experimentally determined profiles for both steady and pulsatile blood flow is made and the agreement is encouraging.
(*h*) **On Steady and Pulsatile Flow of Blood,** T. Ariman, M. A. Turk, N. D. Sylvester, *J. Appl. Mech.* **41**, 1, pp. 1-7, 1974.
On Time-Dependent Blood Flow, T. Ariman, M. A. Turk, N. D. Sylvester, *Letters in Appl. and Eng. Sci.* **2**, pp. 21-36, 1974.

117-08904-130-00

MICROCONTINUUM FLUID MECHANICS

(*c*) Assoc. Professor T. Ariman.
(*d*) Theoretical, basic research.
(*e*) Recently a new branch of fluid mechanics has been evolving which involves a reformulation of the mechanical concepts of classical fluid mechanics to account for the micromotions and deformations of suspensions in fluid flow. There have been a number of microcontinuum theories developed to describe the mechanical behavior of rheologically complex fluids. An extensive survey of microcontinuum fluid mechanics was recently presented by Ariman, et al. Owing to its relative mathematical simplicity compared with the general theories of microfluids, a special theory for fluids with rigid suspensions (the theory of micropolar fluids) has been successfully applied to a number of flow problems in fluid mechanics.
(*h*) **Applications of Microcontinuum Fluid Mechanics,** T. Ariman, M. A. Turk, N. D. Sylvester, *Intl. J. Eng. Sci.* **12**, pp. 273-293, 1974.
Microcontinuum Fluid Mechanics, T. Ariman, M. A. Turk, N. D. Sylvester, *Intl. J. Eng. Sci.* **11**, pp. 905-930, 1973.

117-08905-230-52

SHOCK IN SUPERHEATED FLUIDS

(*b*) Energy Research and Development Administration.
(*c*) Assoc. Professor H. Atassi.
(*d*) Theoretical, basic research.
(*e*) Intense nuclear or laser beam releases a large amount of energy along its trajectory as it crosses a fluid. This would produce thermal and mechanical waves and then cavitation. This effect is used to some extent in bubble chambers. The study proposes to determine the conditions for a mechanical shock and its interaction with the thermal field.

117-08906-890-54

FIRE AND SMOKE SPREAD IN CORRIDORS

(*b*) National Science Foundation.
(*c*) Professors K. T. Yang, J. R. Lloyd, M. L. Doria, V. W. Nee, and A. A. Szewczyk.
(*d*) Theoretical and experimental, basic and applied research.
(*e*) This study is directed toward a better understanding of fire and smoke spread, and is to be accomplished through the development of numerical analytical models which can be used for predictive as well as guidance purposes. Radiation effects will be fully accounted for in these models. Data gathered at NBS and the University of Notre Dame will be used for an assessment of the validity of the analytical approach. The analysis will be applied to small-scale and full-scale fire spread problems such as the E-84 tunnel, model corridors, the full-scale corridor, to mention a few applications. With the availability of such an analysis, the relationship in terms of scaling between full-scale and small-scale tests can be examined. The analysis can be used for guidance on the usefulness of hazard tests as well as explaining the behavior of full-scale tests.

117-08907-140-54

HEAT TRANSFER IN NEAR SUPERCRITICAL TURBULENT FLOW IN PIPES

(*b*) National Science Foundation.
(*c*) Professor K. T. Yang.
(*d*) Theoretical and experimental, basic research.
(*e*) Develop a rational semi-empirical theory based on relevant physical mechanisms which are known to affect the heat transfer characteristics for turbulent pipe flow of near supercritical fluids. Anomalies relative to pipe size, pipe orientation, and level of heat flux with existing data will be examined in detail. A supercritical heat transfer test loop will be constructed with sufficient flexibility to accommodate both internal and external flow situations, so that individual physical mechanisms can be separately controlled and studied. Carbon dioxide is the working fluid.

117-08908-140-54

RADIATION INTERACTION IN CONVECTIVE HEAT TRANSFER

(*b*) National Science Foundation.
(*c*) Assoc. Professor J. R. Lloyd and Professor K. T. Yang.
(*d*) Theoretical and experimental, basic research.
(*e*) An analytical and experimental investigation of the interaction of thermal radiation with convection. The investigation will center on situations arising in combustion problems such as non-homogeneous gases and geometries that require finite-difference solutions. Although this proposal is centered on two specific problems, the basic knowledge gained from this research can be extended to other situations where the interaction of radiation with the other modes of heat transfer is important. The ability of being able to realistically predict the influence of radiation on heat transfer in furnaces, combustors, and unwanted fire spread as well as on pollutant formation, to cite a few examples, is extremely important.

UNIVERSITY OF NOTRE DAME, Department of Civil Engineering, Notre Dame, Ind. 46556. Dr. Don A. Linger, Department Chairman.

118-08213-820-33

HYDROGEOLOGIC FACTORS INVOLVED IN PREDICTING THE EFFECTS OF SANITARY LANDFILL OPERATIONS ON GROUNDWATER QUALITY

(*b*) Office of Water Resources Research.
(*c*) P. C. Singer, J. E. Lindell, J. J. Marley, E. M. Winkler.
(*d*) Theoretical, experimental and field investigation.
(*e*) Determine the effects of solid waste disposal by sanitary landfill methods upon groundwater quality and to relate this effect to rainfall infiltration measurements and to the soil and geological characteristics at the disposal site. These relationships will be used to develop a predictive model for groundwater quality as a function of the several pertinent hydrogeologic parameters.
(*g*) It has been found that several water quality parameters including chemical oxygen demand (COD), hardness, al-

kalinity, conductivity, and ammonia are significantly higher in samples of groundwater collected from the discharge side of the St. Joseph County, Indiana Sanitary Landfill than in samples collected from a control well. Some of these parameters exhibit a consistent relationship to hydrologic activity as expressed by a rainfall antecedent, with peak concentrations lagging peak antecedent by a regular interval. During the winter months when the ground is frozen and infiltration is inhibited the same parameters are significantly lower in concentration than during the summer months following heavy infiltration.

(*h*) **Groundwater Pollution from the St. Joseph County, Indiana Sanitary Landfill: Hydrologic Aspects,** K. S. Stachiw, *M.S. Thesis*, 1972.
Trace Metals and Organic Material in Northern Indiana Ground Water Public Drinking Supplies, J. H. Mulligan, *M.S. Thesis*, 1974.
Mathematical Modeling of Groundwater Contaminant Dispersion, G. Aguirre, *M.S. Thesis*, 1974.

18-08909-870-36

NTERDISCIPLINARY EVALUATION OF EUTROPHIC LAKE RESTORATION

(*b*) Environmental Protection Agency.
(*c*) R. L. Irvine, T. L. Theis, Q. Ross, and R. Greene.
(*d*) Theoretical, experimental and field investigation; M.S. and Ph.D. theses.
(*e*) Demonstrate on a full-scale basis, a lake reclamation method, using a fly ash and lime treatment. The initial phases of the project have been devoted to research and development of the treatment methodology. The present project is devoted to the actual application of fly ash and lime to the east side of Lake Charles East which is a 20 acre over nutrified lake in Steuben County, Indiana. The emphasis of this project is the monitoring of the results of the treatment of the 7.2 acres of the east portion of the lake as compared to the control (west) side of the lake. Differences in the physical, chemical and biological characteristics between the treated and control sides will be noted with particular interest in the success of the treatment in retarding algal blooms and their related problems will be evaluated. In addition, the potential detrimental effects of the treatment method on higher trophic levels will be monitored. Water quality will be monitored to determine the probability of trace metal release downstream from the treated portion of the lake.
A second aspect of this project is to study some of the various aspects of lake eutrophication which are directly or indirectly related to reclamation methods by physical and chemical manipulation. Continued laboratory algal assay studies will be performed to determine algal regrowth in treated water, and the effect of cations on phosphorus uptake. Study is currently underway to determine the rate and extent of nutrient regeneration from algal decomposition and the availability of these nutrients for further algal growth during a growing season. Continued evaluation of trace metal releases from fly ash treatment will be conducted both in the laboratory and on a field basis in Lake Charles East as well as the uptake of these metals in the biological community. Another study will analyze the effect of fly ash on the growth, regrowth, and distribution of macrophytes in the lake.
(*g*) Results have indicated the usefulness of fly ash and lime for the removal of excessive phosphorous nutrient from lake waters and the sealing of the sediments to avoid rerelease from the lake bottom sediments. However, the results also have shown the critical aspects of the fly ash lime addition procedures and the importance of the phytoplankton cycles in the treatment of eutrophic lakes.
(*h*) **The Use of Particulates to Control Phosphate Release from Eutrophic Lake Sediments,** S.M. Yaksich, *Ph.D. Thesis*, 1972.
Mathematical Modeling of Lake Systems With Nutrient Cycling, C. F. Cordeiro, *Ph.D. Thesis*, 1975.
The Effects of Lake Reclamation on the Biotic Community, T. K. Hampton, *M.S. Thesis*, 1973.
Dynamic Mathematical Model of Algal Growth in Eutrophic Freshwater Lakes, V. J. Bierman, Jr., *Ph.D. Thesis*, 1974.
Studies on Phosphorus and Nitrogen Regeneration: The Effect of Aerobic Bacteria on Phytoplankton Decomposition and Succession in Freshwater Lakes, J. V. DePinto, *Ph.D. Thesis*, 1975.

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NUS CORPORATION, Environmental Safeguards Division, Hydrology and Geology Department, 4 Research Place, Rockville, Md. 20850.

119-08910-070-52

CONTAMINANT REDISTRIBUTION IN SATURATED POROUS MEDIA WITH GENERAL DEPOSITION PROFILE AND VARIABLE TRANSPORT VELOCITY

(*b*) Energy Research and Development Administration.
(*c*) Dr. Robert H. Turner and Robert J. Kennett.
(*d*) Theoretical; basic and applied research.
(*e*) A closed form analytic expression is developed to mathematically model the transport of an initially deposited contaminant into water saturated soil. Downward water motion causes the redistribution into a one-dimensional, semi-infinite, homogeneous, porous medium, with a zero-flux boundary condition of the third kind at the surface. Space-time profiles can be generated for any initial profile by constructing the profile from a basic step solution.
(*g*) Solution profile sets for different initial concentration profiles indicate that the initial profile has a persisting influence on the maximum concentration. Attenuation due to decay or adsorption is considered when the decay is proportional to local concentration. The average contaminant flow velocity $V(t)$ and dispersion coefficient $D(t)$ can vary with time, although the ratio $V(t)/D(t)$ must be constant. A unique set of profiles always occurs regardless of velocity variation.
(*h*) Presented *Fall Ann. Mtg., Amer. Geophys. Union*, Dec. 1974. Submitted for publication.

119-08911-070-52

CONTAMINANT CONCENTRATION REDISTRIBUTION PROFILES IN SOILS RESULTING FROM SUCCESSIVE INFILTRATION EVENTS

(*b*) Energy Research and Development Administration.
(*c*) Dr. R. H. Turner and R. J. Kennett.
(*d*) Theoretical; basic and applied research.
(*e*) A contaminant of microparticulate form initially deposited near the soil surface is transported down due to the infiltration component of rain. The advancing wet front is modeled as an abrupt demarcation line between saturated and unsaturated soil, and the wet front generally moves faster than the bulk water velocity behind it when the soil initially contains some moisture.
(*g*) Local concentration buildups occur as the wet front advances through the concentration profile. Depending on the infiltration schedule of successive inundations large accumulations of contaminant occur due to successive deposition.
(*h*) Presented *Fall Ann. Mtg., Amer. Geophys. Union*, Dec. 1974.

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OAKLAND UNIVERSITY, School of Engineering, Rochester, Mich. 48063. Dr. P. R. Paslay, Dean of Engineering.

121-08912-130-54

TWO-PHASE EVAPORATING FLOW PHENOMENA

(*b*) National Science Foundation.
(*c*) Dr. G. L. Wedekind, Assoc. Professor of Engineering.
(*d*) Experimental and theoretical; basic research.

(e) A study is being conducted into various deterministic and statistical characteristics associated with horizontal two-phase evaporating flow where complete vaporization takes place.

(g) Experimental evidence indicates that during what is conventionally accepted as steady flow conditions, the motion of the mixture-vapor transition point (liquid film dryout point) is of an oscillatory nature. Furthermore, not only are the oscillations random, but their statistical characteristics can be represented by a modified Rayleigh distribution. A theoretical model has been formulated which incorporates various deterministic mechanisms, while at the same time includes the existence of a random phenomenon. The model has the capability of predicting the influence of evaporator heat flux and inlet flow quality on the statistical characteristics of the transition point oscillations. Perhaps, the most significant potential of the proposed model is that it represents a first step toward the formulation of some of the fundamental mechanisms associated with two-phase evaporating flow instabilities on a statistical basis; a basis which appears to be consistent with many of the experimental observations currently available.

(h) **Theoretical Model of the Mixture-Vapor Transition Point Oscillations Associated With Two-Phase Evaporating Flow Instabilities,** G. L. Wedekind, B. T. Beck, *ASME J. Heat Transfer* **96,** 2, pp. 138-144, May 1974.
Correlation Between Outlet Flowrate and Mixture-Vapor Transition Point Oscillations in Two-Phase Evaporating Flow, G. L. Wedekind, B. T. Beck, *Proc. 5th Intl. Heat Transfer Conf.* **4,** pp. 220-224, Tokyo, Japan, Sept. 1974.

OAK RIDGE NATIONAL LABORATORY (see HOLIFIELD NATIONAL LABORATORY listing).

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, Department of Agricultural Engineering, Wooster, Ohio 44691.

122-0165W-890-00

STABILIZATION OF STEEP LAND SLOPES

(e) For summary, see Water Resources Research Catalog **6,** 8.0450.

122-08913-840-00

DRAINAGE SYSTEM DESIGN FOR POLLUTION CONTROL AND CROP PRODUCTION

(c) Dr. G. O. Schwab, 2073 Neil Ave., Ohio State University, Columbus, Ohio 43210.

(d) Experimental investigation, applied research.

(e) Field experiments have been in progress since 1958 to evaluate subsurface and surface drainage systems for crop production and for quantities and kinds of suspended and soluble material in the drainage water. Small lysimeters have been taken from four soils to evaluate water table height on plant growth. Effects of tillage and drainage on soil characteristics are also being evaluated. Project revised in 1972. See summaries in Water Resources Research Catalog **9,** 2.0816 and 4.0163.

(g) On Toledo silty clay soil hay yields were 0.68, 1.66, 2.20, and 3.22 tons/ac. for drainage treatments of plastic tubing, surface only, tile only, and tile plus surface, respectively. For surface only and tile drainage only, respectively, losses in lbs./acre in 1973 were 6571 and 4001 for sediment; 8.5 and 19.6 for NO_3N; 2.3 and 1.75 for phosphorus; and 82.1 and 51.1 for potassium. The corresponding runoff (Mar.-Sept.) was 9.9 and 7.0 inches.
In the two tile drained treatments soil in the plow layer had 150 percent higher hydraulic conductivity, 20 percent lower compressive strength, and 60 percent lower surface crust resistance to pentration than the plastic tubing and the surface drained treatments. Because the plastic tubing plots were previously undrained, measurements were affected by pretreatment conditions.
The average hay yields from small lysimeters averaged 2.07, 3.27, 4.39, and 4.02 tons/ac. for Hoytville, Toledo, Genessee, and Brookston soils, respectively. The soil drained freely throughout the year from the lysimeters.

(h) **Comparison of Drainage Methods in a Heavy-Textured Soil,** G. O. Schwab, N. R. Fausey, D. W. Michener, *Trans. Am. Soc. Agr. Eng.* **17,** 3, pp. 424-428.
Chemical and Sediment Movement from Agricultural Land into Lake Erie, G. O. Schwab, E. O. McLean, *Supplement Rept. Project 390X,* Water Resources Center, Ohio State Univ., 1973.
Quality of Drainage Water from a Heavy-Textured Soil, G. O. Schwab, E. O. McLean, A. C. Waldron, R. K. White, D. W. Michener, *Trans. Am. Soc. Agr. Eng.* **16,** 6, pp. 1104-1107, 1973.

OHIO STATE UNIVERSITY, Department of Agronomy, Columbus, Ohio 43210. Professor George S. Taylor.

123-06734-820-33

WELL DRAWDOWN IN UNCONFINED AQUIFERS UNDER NON-STEADY CONDITIONS

(d) Experimental investigations; applied research.

(e) A numerical analysis study of drawdown around wells in unconfined porous media for transient conditions. The simultaneous flow of water in both the saturated and unsaturated flow regions is evaluated for various pumping rates and boundary conditions. The entire operation is programmed on an IBM 360 computer. Fulfillment of the project objectives will yield computer techniques for handling complicated water flow problems and additional information on inflow into wells.

(g) Drawdown in the near vicinity of wells has been evaluated for porous media which differ in permeability and specific yield. The feasibility of utilizing computer operation for rapid analysis of complex flow problems has been demonstrated.

(h) **Theoretical Two-Dimensional Analysis of Natural Rainfall Infiltration Into a Sloping Plane,** E. U. Nwa, G. S. Taylor, R. B. Curry, E. P. Taiganides, *J. Agric. Engrg. Res.* **19,** pp. 281-292, 1973.

OHIO STATE UNIVERSITY, Department of Chemical Engineering, Columbus, Ohio 43210. Aldrich Syverson, Department Chairman.

124-07551-010-54

A VISUAL INVESTIGATION OF THE LAMINAR-TURBULENT TRANSITION

(b) National Science Foundation.

(c) Robert S. Brodkey or Harry C. Hershey.

(d) Experimental; basic; Doctoral theses.

(e) An experimental study into the basic mechanism of the entire laminar turbulent transition for both boundary layer and pipe flow, to elucidate clearly the steps that occur in the transition from laminar to turbulent flow and to clarify which, if any, theories apply for the various steps known to exist.

124-07552-020-54

TURBULENT MOTION AND MIXING

(c) Robert S. Brodkey.

(d) Experimental and theoretical; basic; Doctoral thesis.

(e) An experimental and theoretical approach to the basic interactions of turbulence and the mixing of a scalar quantity such as mass. Mixing of heat or mass in a turbulent field

can in principle be determined from a knowledge of the existing turbulence in the system and the molecular properties of the material being mixed. The object is to accomplish this prediction.

(*f*) Completed, publications being prepared.

(*g*) A number of papers have been published by the investigators of this work. We have been able to accomplish the prediction for pipe flow and are now working on a reactor configuration. Furthermore, we have been successful in extending the analysis to the prediction of the effect on chemical kinetics.

(*h*) **Mixing and Recycle for Analysis of a Continuous Flow Stirred Tank,** R. S. Brodkey, M. A. Rao, *Chem. Eng. Sci.* **27,** 2199, 1972.

Turbulent Motion, Mixing, Kinetics, *Fluid Mechanics of Mixing* (invited paper), ASME, N.Y., 1973.

Continuous Flow Stirred Tank Turbulence Parameters in the Impeller Stream, R. S. Brodkey, M. A. Rao, *Chem. Engrg. Sci.* **27,** p. 137, 1972.

124-07553-250-54

A VISUAL INVESTIGATION OF DRAG REDUCTION AND DRAG REDUCTION IN NONAQUEOUS SOAP SOLUTIONS

(*b*) National Science Foundation.

(*c*) Harry C. Hershey.

(*d*) Experimental; basic; Doctoral theses.

(*e*) Experimental study into the basic mechanism of drag reduction in pipe flow using high molecular weight polymer or soap solutions and into the laminar and turbulent behavior of soap solutions. Flow in the wall region of a drag reducing fluid is being compared visually to the flow of a pure solvent. The technique involves high speed photography of colloidal-size particles. A parallel investigation is studying the laminar and turbulent behavior of various aluminum soaps in nonaqueous solvents.

124-08216-010-54

VISUAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER

(*b*) National Science Foundation.

(*c*) Robert S. Brodkey or Harry C. Hershey.

(*d*) Experimental; basic; Doctoral theses.

(*e*) An experimental study into the basic mechanism of boundary layer flow with emphasis on the interaction of the inner and outer regions. Presently stereo movies of turbulence events are being taken.

(*h*) **The Wall Region in Turbulent Flow,** Engrg. Societies Library, 16 mm Sound Movie B and W, 1972.

The Wall Region in Turbulent Shear Flow, J. M. Wallace, H. Eckelmann, R. S. Brodkey, *J. Fluid Mech.* **54,** p. 39, 1972.

A Visual Study of Turbulent Shear Flow, H. C. Hershey, R. S. Brodkey, *J. Fluid Mech.* **61,** p. 513, 1973.

Turbulent Kinetic Energy, Dissipation and Diffusion, R. S. Brodkey, J. Taraba, S. Nychas, J. Wallace, *Phys. Fluids* **16,** p. 2010, 1973. Short version published in *Zeitschrift fur Angewandte Mathematick und Mechanik* **54,** 4, T137, 1974.

Some Properties of Truncated Turbulence Signals in Bounded Shear Flows, R. S. Brodkey, J. M. Wallace, H. Eckelmann, *J. Fluid Mech.* **63,** p. 209, 1974.

A Visual Study of Turbulent Shear Flow, Engrg. Societies Library, 16 mm Sound Movie B and W, 1974.

OKLAHOMA STATE UNIVERSITY, School of Mechanical and Aerospace Engineering, Stillwater, Okla. 74074. Dr. K. N. Reid, Head.

125-08938-250-13

DRAG REDUCTION IN DREDGE-SPOIL PIPE FLOWS

(*b*) U. S. Army Engineers, Waterways Experiment Station, Vicksburg, Miss.

(*c*) Dr. W. G. Tiederman.

(*d*) Experimental, applied research for Master's thesis.

(*e*) Determine the preliminary feasibility of reducing the viscous drag in pipe flows of dredge spoil.

(*f*) Completed.

(*g*) As much as 70 percent drag reduction can be achieved with the addition of 100 ppm of SEPARAN AP273 to dredge spoil. However, the amount of drag reduction decreases substantially as the total solids content of the spoil increases.

(*h*) **Drag Reduction in Dredge-Spoil Pipe Flows,** J. E. Herod, W. G. Tiederman, *J. Hydraul. Div., Proc. ASCE* **100,** HY12, pp. 1863-1866, Dec. 1974.

125-08939-250-54

FLOW VISUALIZATION OF DRAG REDUCING CHANNEL FLOWS

(*b*) National Science Foundation.

(*c*) Dr. W. G. Tiederman.

(*d*) Experimental basic research for Ph.D. and M.S. theses.

(*e*) The flow processes in the near-wall region of a fully developed, turbulent, two-dimensional channel flow are being studied. The flow processes are marked by dye, photographed and then analyzed to determine how small concentrations of long-chain polymer molecules alter the flow structure and thereby lower the viscous friction.

(*g*) Generally the polymer additives suppress the momentum exchange between the near-wall region of the flow and the outer region. While none of the mixing processes are totally suppressed, some are altered. As the amount of drag reduction increases, the high-momentum eddies in the outer regions of the flow do not pentrate as close to the wall. The characteristics of the longitudinal eddy structure in the wall region also change. The average spanwise spacing of these eddies increases as drag reduction increases. Similarly, the spatially averaged bursting rate of these low-momentum streaks also decreases as drag reduction increases.

(*h*) **Flow Visualization of the Near-Wall Region in a Drag-Reducing Channel Flow,** G. L. Donohue, W. G. Tiederman, M. M. Reischman, *J. Fluid Mech.* **56,** p. 559, Dec. 1972.

The Effect of Drag Reduction Upon Flow in the Near-Wall Region, D. K. Oldaker, W. G. Tiederman (a silent 16 mm movie, available from Audio Visual Center, Okla. State Univ.). Presented *BHRA Intl. Conf. on Drag Reduction,* Cambridge, England, Sept. 1974.

125-08940-700-00

LASER DOPPLER ANEMOMETRY FOR TURBULENT FLOWS

(*c*) Dr. W. G. Tiederman, and Dr. D. K. McLaughlin.

(*d*) Experimental and theoretical; basic research; for several Masters and Doctoral theses.

(*e*) Develop the experimental technique of individual realization laser Doppler anemometry for the measurement of highly turbulent fluid flows. Major emphasis is placed on data reduction algorithms which account for natural statistical biasing and finite probe volume biasing errors.

(*g*) The technique has been successfully used to measure the mean velocity and turbulence intensities in several flow situations including a jet in cross flow, fully developed turbulent channel flow of water, and drag reducing channel flows of polymer solutions. Corrections have been developed to account for statistical biasing of the data.

(*h*) **Turbulence Measurements With a Laser Anemometer Measuring Individual Realization,** G. L. Donohue, D. K. McLaughlin, W. G. Tiederman, *Phys. Fluids* **15,** p. 1920, Nov. 1972.

Determination of Laser Power Requirements for Laser Doppler Anemometers, P. J. Wallen, *M.S. Thesis,* Okla. State Univ., Aug. 1973.

Individual Realization Laser Doppler Technique Applied to Turbulent Channel Flow, W. G. Tiederman, D. K. McLaughlin, M. M. Reischman, *3rd Biennial Symp. on Turbulence in Liquids,* Univ. of Missouri-Rolla, Sept. 1973.

A Digital Signal Processor for Laser Doppler Anemometer Systems, L. N. Salsman, *M.S. Thesis*, Okla. State Univ., Dec. 1973.
Laser Anemometer Measurements in Drag-Reducing Channel Flows, M. M. Reischman, *Ph.D. Thesis*, Okla. State Univ., Dec. 1973 (Univ. Microfilm).
Biasing Correction for Individual Realization Laser Anemometer Measurements in Turbulent Flows, D. K. McLaughlin, W. G. Tiederman, *Phys. Fluids* **16**, p. 2082, Dec. 1973.
A Laser Doppler Anemometer for Viscous Sublayer Measurements, M. E. Karpuk, W. G. Tiederman, *Intl. Workshop on Laser Velocimetry*, Purdue Univ., Mar. 25-29, 1974.
Evaluation of a Sequential Phase Comparison Data Processor for Laser Anemometry, L. N. Salsman, W. R. Adcox, D. K. McLaughlin, *Intl. Workshop on Laser Velocimetry*, Purdue Univ., Mar. 25-29, 1974.
A Laser Doppler Anemometer for Viscous Sublayer Measurements, M. E. Karpuk, *M.S. Thesis*, Okla. State Univ., May 1974.
Evaluation of a Sequential Phase Comparator for the Reduction of Laser Anemometry Data, W. R. Adcox, *M.S. Thesis*, Okla. State Univ., Dec. 1974.
Laser Doppler Anemometer Measurements in Drag Reducing Channel Flows, M. M. Reischman, W. G. Tiederman, *J. Fluid Mech.*, in press.

125-08941-440-61

HYDRAULIC MODELING OF MIXING IN STRATIFIED LAKES

(*b*) Oklahoma Water Resources Research Institute.
(*c*) Dr. P. M. Moretti and Dr. D. K. McLaughlin.
(*d*) Experimental, applied research for several M.S. theses.
(*e*) Lake models with vertical distortion and saline stratification are used to develop methods of modeling the dispersion of inflows and the operation of mechanical destratification devices. Results are verified against data from the prototype lakes.
(*g*) Destratification processes can be modeled by maintaining prototype Richardson number, on a time scale derived from the ratio of total water volume to the volume flow rate. The lower Reynolds numbers in the model lead to somewhat more abruptly stepped density profiles.
(*h*) **Similitude Investigation of Vertical Exaggeration in Stratified Lake Models,** S. J. Vogel, *M.S. Thesis*, Okla. State Univ., July 1973.
Investigation of Artificial Lake Destratification – A Hydraulic Model Study, T. A. Gibson, *M.S. Thesis*, Okla. State Univ., July 1974.
Modeling Inflows Into Stratified Lakes with Vertical Scale Distortion, G. E. Kouba, *M.S. Thesis*, Okla. State Univ., July 1974.
Mixing Phenomena in Stratified Lakes, P. M. Moretti, D. K. McLaughlin, *Rept. ER-75-ME-1*, School of Mech. and Aerospace Engrg., Okla. State Univ., Stillwater, Okla., 1974.

OLD DOMINION UNIVERSITY, Institute of Oceanography, Norfolk, Va. 23508. Dr. John C. Ludwick, Institute Director.

126-08217-220-20

SAND WAVES IN THE TIDAL ENTRANCE TO CHESAPEAKE BAY, VIRGINIA

(*b*) Office of Naval Research.
(*d*) Field investigation; basic research; M.S. theses.
(*e*) To elucidate the connection between sand waves and large sand banks in the tidal entrance to Chesapeake Bay, Virginia. In transverse profile the sand waves include symmetrical and asymmetrical-trochoidal types. By successive bathymetric surveys the migration direction and travel rates of the various types are to be determined. Tidal flows are reversing, unequal, and the degree of dominance varies with geographic position relative to banks and channels. Charting of the net current pattern should also shed light on the evolution of the shoals. Bed shear stress deduced from the vertical distribution of current speed is to be used to estimate net bed sediment transport rate over the area.
(*f*) Completed.
(*g*) Migration rate of asymmetrical waves was 115 to 492 ft/year seaward.
(*h*) **Tidal Currents and Zig-Zag Sand Shoals in a Wide Estuary Entrance,** J. C. Ludwick, *Bull. Geol. Soc. America* **85**, pp. 717-726.

126-08914-450-44

HYDRAULIC SENSOR INSTRUMENTATION OF A SHORE FACE IN A TIDAL, NON-TIDAL CURRENT CONVERGENCE ZONE – CAPE HENRY, VIRGINIA

(*b*) National Oceanic and Atmospheric Administration – Environmental Research Laboratory.
(*d*) Field investigation; applied research.
(*e*) Tide, wave, and current sensors are mounted on a sea floor tripod and hard-wired to shore. The purpose is to learn how to separate wave surge from other current fields.

OREGON STATE UNIVERSITY, School of Engineering, Corvallis, Oreg. 97331. W. L. Schroeder, Acting Associate Dean of Engineering.

127-07556-860-36

TIDAL FLATS IN ESTUARINE WATER QUALITY ANALYSIS

(*b*) Environmental Protection Agency.
(*d*) Experimental and theoretical; applied.
(*e*) The project has focused attention on estuarine benthic system. The sulfur cycle has been examined.
(*f*) Completed.
(*g*) Mathematical modeling procedures have been examined. Estuarine benthic systems have been described. Rates of sulfate reduction have been measured.
(*h*) **Role of Tidelands and Marshlands in Estuarine Water Quality,** D. A. Bella, *Proc. Northwest Estuarine and Coastal Zone Symp.*, 1970.
Finite Difference Convection Errors, D. A. Bella, W. J. Grenney, *J. San. Engrg. Div., ASCE* **96**, pp. 1352-1361, 1970.
In Situ Measurements of the Benthal Oxygen Requirements of Tidal Flats, G. R. Crook, D. A. Bella, *Proc. 23rd Industrial Waste Conf.*, Purdue Univ., 1970.
Effects of Mixing on Oxygen Uptake Rate of Estuarine Bottom Deposits, D. C. Martin, D. A. Bella, *J. Water Poll. Control Fed.* **43**, 9, Sept. 1971.
Environmental Considerations for Estuarine Dredging Operations, D. A. Bella, J. E. McCauley, *IV Proc. World Dredging Conf.*, New Orleans, La., 1971.
Effects of Tidal Flats on Estuarine Water Quality, D. A. Bella, A. E. Ramm, P. E. Peterson, *J. Water Poll. Control Fed.* **44**, 4, pp. 541-556, April 1972.
Estimating Dispersion Coefficients in Estuaries, D. A. Bella, W. J. Grenney, *J. Hydraul. Div., ASCE* **98**, HY3, Tech. Note, pp. 583-589, Mar. 1972.
Environmental Considerations for Estuarine Benthal Systems, D. A. Bella, *Water Res.* **6**, pp. 1409-1418, 1972.
Sulfide Production in Anaerobic Microcosms, A. E. Ramm, D. A. Bella, *Limnol. and Oceanog.* **19**, 1, Jan 1974.

127-07558-860-33

COMPUTER SIMULATION OF EUTROPHICATION

(*b*) Office of Water Resources Research.
(*c*) David A. Bella, Assoc. Professor, Dept. of Civil Engineering.
(*d*) Theoretical; applied.
(*e*) Computer models are employed to examine aquatic ecosystems.
(*f*) Completed.
(*g*) Dissolved oxygen model of stratified lake developed and examined. Importance of algal sinking and vertical mixing studied. Algal model including nutrient storage developed. Comprehensive environmental planning and role mathematical modeling examining.
(*h*) **Simulating the Effects of Sinking and Vertical Mixing on Algal Population Dynamics,** D. A. Bella, *J. Water Poll. Control Fed.* 42:5, 2. pp. R140-152, May 1970.
Diel Overturning in Lakes, S. L. Smith, D. A. Bella, presented *Pacific Northwest AGU Conf.*, Oregon State Univ., Corvallis, 1971.
Dissolved Oxygen and Temperature in a Stratified Lake, S. A. Smith, D. A. Bella, *J. Water Poll. Control Fed.* **45'1,** pp. 119-133, Jan. 1973.
Dissolved Oxygen Variations in Stratified Lakes, D. A. Bella, *J. San. Engrg. Div., ASCE* **96,** *SA5 Proc. Paper 7628*, pp. 1129-1146, Oct. 1970.
A Mathematical Model of the Nutrient Dynamics of Phytoplankton in a Nitrate Limited Environment, W. J. Grenny, D. A. Bella, H. C. Curl, Jr., *Biotech. and Bioeng.* **15,** 225, 1973.
A Mathematical Model of the Effects of Intercellular Nutrient Pools in Phytoplankton on Community Growth Dynamics, W. J. Grenney, D. A. Bella, H. C. Curl, Jr., *J. Water Poll. Control Fed.* **46,** 7, pp. 1751-1760, July 1974.
Ecological Importance of Temporal Variations, D. A. Bella, (Technical Note), *J. San. Engrg. Div., ASCE* **98,** SA4, pp. 685-691, Aug. 1972.
A Theoretical Approach to Interspecific Competition in Phytoplankton Communities, W. J. Grenny, D. A. Bella, H. C. Curl, Jr., *American Naturalist* **107,** 955, pp. 405-425, May-June 1973.
Environmental Planning and Ecological Possibilities, D. A. Bella, W. S. Overton, *J. San. Engrg. Div., ASCE* **98,** SA3, pp. 579-592, June 1972.
Computer Simulation of Eutrophication, D. A. Bella, Dept. of Civil Engrg., Oregon State Univ., Corvallis, 97331.

127-09729-880-33

DEVELOPMENT OF ENVIRONMENTAL STRATEGIES WITH SPECIFIC APPLICATION TO OREGON ESTUARIES

(*b*) Office of Water Resources Research.
(*c*) David A. Bella, Assoc. Professor, Dept. of Civil Engineering.
(*d*) Theoretical; applied.
(*e*) Inventory of Oregon's estuaries completed, comprehensive, strategic, approach to environmental planning examined.
(*f*) Phase I completed, Phase II active.
(*g*) The meaning of strategic planning has been examined. A number of strategic concepts have been developed. These concepts attempt to accommodate unexpected environmental outcomes and pursue a more meaningful fulfillment of human potentialities. The importance of environmental research in the management process has been examined.
(*h*) **Fundamentals of Comprehensive Environmental Planning,** D. A. Bella, *Engrg. Issues-J. Professional Activities, ASCE* **100,** E11, pp. 17-36, Jan. 1974.
Strategic Approach to Environmental Management, *J. Waterways, Harbors and Coastal Engrg., ASCE* **101,** Feb. 1975.
Conflicts in Interdisciplinary Environmental Research, D. A. Bella, K. J. Williamson (publication pending).
Applied Interdisciplinary Research and Environmental Management, D. A. Bella, K. J. Williamson, *Learning for Survival – A Symposium on Environmental Education and Water Quality for the Future*, Expo 74, Spokane, Wash., Oct. 1974 (in press).

OREGON STATE UNIVERSITY, School of Engineering, Ocean Engineering Programs, Corvallis, Oreg. 97331. Dr. Larry S. Slotta, Programs Director.

128-09764-470-44

HYDRAULIC CHARACTERISTICS OF MARINAS: A CASE STUDY OF BROOKINGS, OREGON

(*b*) U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.
(*c*) Dr. L. S. Slotta, Professor of Civil Engrg. and S. Klein, Research Asst. in Civil Engrg., Ocean Engineering Programs.
(*d*) To compare predicted mixing and diffusion times with those occurring after the 1975 opening of the Port of Brookings new boat basin. If the marina exhibits poor exchange characteristics, studies of potential corrective actions will need to be initiated.
(*e*) The following studies will be done regarding the Port of Brookings new boat basin operations: 1) Field studies prior to and following construction including tidal height and progressive dampening upstream of Chetco River, tidal volume flushing measurements, river discharges, bay-ocean exchange; 2) seasonal monitoring following basin opening and during operation, marina flushing and diffusion times, water mass trajectories, water quality parameters; 3) laboratory studies to include scale model construction with adjustment and calibration for tides and flows – with and without marina expansion flushing simulation and stagnation corrective techniques; numerical model application; and analytical model application; and 4) stagnation corrective field procedure examination.
(*g*) Insufficient data to date.

128-09765-430-44

WAVE INTERACTION WITH MOORED FLOATING STRUCTURES: PHASE TWO

(*b*) U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.
(*c*) C. K. Sollitt, Asst. Professor of Civil Engrg., Ocean Engineering Programs.
(*d*) Determine the magnitude of scale effects which result from extending model results to prototype scale via Froude scaling laws; to extend these results to random wave excitation to simulate windwave sea states; to develop more sophisticated analytical models for improving predictive capabilities in lieu of hydraulic models; and to provide insights into the behavior of moored floating structures.
(*e*) Specific tests will be conducted by exposing a model equipped with accelerometers and load cells to a well-behaved spectrum (Pierson-Moskowitz) under conditions of varying water depth and mooring line scope and tension. Data analysis will include comparison of monochromatic and random wave transfer functions.
(*g*) Insufficient data to date.

128-09766-430-44

APPLICATIONS OF NONLINEAR RANDOM SEA SIMULATIONS FOR DESIGN OF OFFSHORE STRUCTURES

(*b*) U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.
(*c*) R. T. Hudspeth, Asst. Professor of Civil Engrg., Ocean Engineering Programs.
(*d*) To expand methods for simulating a time sequence of nonlinear random seas by digital computer and to estimate second order spectral amplitudes resulting from the non-

linear interactions of a slightly non-Gaussian stochastic process.

(*e*) To estimate the bispectra of hurricane-generated waves and determine the appropriate type of smoothing required; to write a computer program to simulate nonlinear random seas correct to second order using linear spectral estimates for Bretschneider and Borgman methods; to determine the spreading factor which gives the best least squares fit between the four measured realizations and each of the two types of nonlinear simulated realizations; to compare the second-order spectra computed from the two types of linear spectra used in the simulations with the second-order spectral estimates obtained from the measured spectra to evaluate the effects of self-interactions, of cross-product spectral interactions and of outlier spectral estimates; and to compare the probability distributions of the simulated realization with the measured realizations.

(*g*) Results of this study will enable the OSU Wave Research Facility to generate nonlinear random surface waves which will be programmed through a PDP 11/10e computer.

128-09767-430-44

CELLULAR BULKHEAD WHARVES

(*b*) U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.

(*c*) W. L. Schroeder, Assoc. Professor of Civil Engineering.

(*d*) To obtain information with which to interpret data obtained in ongoing full-scale field studies, to relate construction and service conditions to forces and deformations in a circular cell bulkhead, and to develop a rational approach to economical design of circular cell bulkheads.

(*e*) Design and construction of a model with three test series to be conducted which are designed to relate construction configurations of dredge excavation, cell filling, cell compaction, to bulkhead behavior; relate service configurations (surcharge loading) to bulkhead behavior; and relate cell failure modes (sliding, overturning) to cell deformations and sheet pile penetration.

(*g*) Instrumentation was purchased and the model holding basin has been completed. The model sheetpile interlock design and laboratory tests have been completed. A theoretical study of stress distribution in bulkhead fill has been initiated. Results should lead to more economical design procedures.

(*h*) **Instrumentation of a Circular Cell Bulkhead,** W. L. Schroeder, D. Marker, T. Khuayjarernpanishk, *Proc. 12th Symp. Engrg. Geol. and Soils Engrg.*, Boise, 1974.

128-09768-430-44

DESIGN CRITERIA FOR OCEAN AND NEARSHORE STRUCTURES: PHASE II

(*b*) U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.

(*c*) J. H. Nath, Professor of Mechanical Engrg., and T. Yamamoto, Asst. Professor and Senior Scientist in Civil Engrg., Ocean Engineering Programs.

(*d*) The nature of the project is to develop design criteria for difficult ocean engineering problems, i.e., to gain knowledge on the true forces which act perpendicular to and parallel to the nearby boundary represented by the ocean floor, on time-dependent forces from vortex shedding as influenced by the nearby boundary, on the flow regimes, accelerations and velocities around the cylinder which can create devastating scour under pipes, and on the influence on hydrodynamic forces from marine growths which accumulate on pipes and cause deviations from smooth pipe conditions.

(*e*) The OSU Wave Research Facility will be utilized together with a three-inch diameter model mounted with a force measuring section at mid-span which will utilize strain gauge force dynamometers. The distance between cylinder and boundary will be varied as well as wave length, height and water depth. A four-inch diameter cylinder will be used with strain force dynamometers in the test section at mid-span. The OSU Wind Tunnel will be used with wind velocities up to 45 feet per second. Both free stream conditions and submergence in a boundary layer will be investigated. Turbulence measurements will be made behind a smooth cylinder (and if time permits behind the sand-grained roughened cylinders). The turbulence spectra will be recorded in analog form, digitized at the OSU Wave Research Facility. If time permits, an application of the circle theorem to a smooth cylinder near a plane boundary subjected to the velocity potential of a small amplitude wave will be attempted.

(*h*) **Forces From Fluid Flow Around Objects,** J. H. Nath, T. Yamamoto, *Proc. 14th Intl. Conf. Coastal Engrg.*, Copenhagen, June 1974.
Yet Another Report on **Cylinder Drag or Wave Forces on Horizontal Submerged Cylinders** *Engrg. Exp. Sta. Bull. 47*, 139 pages, Oreg. State Univ., Corvallis, Oregon, 1973.
Wave Forces on Cylinders Near a Plane Boundary, T. Yamamoto, J. H. Nath, L. S. Slotta, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **100,** pp. 345-359, Nov. 1974.

128-09769-870-54

AN EXAMINATION OF SOME PHYSICAL AND BIOLOGICAL IMPACTS OF DREDGING IN ESTUARIES

(*b*) Division of Environmental Systems and Resources (RANN), National Science Foundation.

(*e*) Research focus: 1) the effects of dredging on estuarine systems, 2) the system properties of estuaries, 3) the ways in which estuarine research can be used effectively by user groups, and 4) the development of concepts and techniques for monitoring impacts of dredging and other alterations to estuaries.
Field research and laboratory studies were conducted in industrialized Isthmus Slough and compared with research in relatively untouched South Slough on Coos Bay, Oregon. Emphasis was placed on benthic rather than pelagic systems because changes in the sediments are less transitory than those in the over-lying water, and because dredging, by its nature, involves the estuarine bottom.

(*g*) An interdisciplinary mode of research with frequent team dialogue allowed focus on several levels of research ranging from the highly formalized rigorous disciplinary research with its high detail and narrow perspective to an integrated multifaceted approach with less detail and much more perspective. This broad-perspective approach allowed a look at the function of an estuary as part of a physical and social system, and has provided a framework upon which to formulate questions requiring high detail research designed to provide maximum user information. Specific examples include: 1) a general concept of total sulfide capacity (TSC) resulting in a specific chemical test to measure total sulfide capacity, 2) a study of the concept of estuarine stability that has led to specific questions about the role of subtidal clam populations and probable impacts of dredging, and 3) the role of such activities as marine traffic.
The report addresses interdisciplinary research, research progress and results, and the problems of getting results to users.

(*h*) Interim Progress Report: **An Examination of Some Physical and Biological Impacts of Dredging in Estuaries,** submitted to the Division of Environmental Systems and Resources (RANN), National Science Foundation, Washington, D.C., 257 pages, $6.00.

128-09770-870-13

EFFECTS OF SHOAL REMOVAL BY PROPELLER WASH, DECEMBER 1973, TILLAMOOK BAY, OREGON

(*b*) U. S. Army Engineer District, Portland.

(*e*) Findings of the study to determine possible impacts of agitation dredging by the U. S. Army Corps of Engineers dredge, SANDWICK, upon the estuarine system of Tillamook Bay, Oregon, during December 1973. Tests were conducted at selected stations near the dredge site to note effects upon the hydrology, sediment chemistry, water quality, sediment physics, and biology of the bay.

(*f*) Complete, July 1974.

(*g*) The dredge test period was selected concurrent with the times of high runoff because minimum disturbance to economically important fish and invertebrate organisms would then be expected. However, since the dredge moved only a limited amount of material during the test period, it was usually not possible to separate the direct physical, chemical and biological impacts of agitation dredging from the masking effects of the natural freshwater runoff and winter weather. This fact, and the study findings, indicate that the SANDWICK would have little or no environmental impact when dredging under similar conditions elsewhere, provided that limited volumes of material were to be moved.

(*h*) **Effects of Shoal Removal by Propwash (December 1973) in Tillamook Bay, Oregon,** L. S. Slotta, D. H. Hancock, K. J. Williamson, C. K. Sollitt, 155 pages,, 1974, $4.50.

128-09771-870-13

EFFECTS OF HOPPER DREDGING AND IN-CHANNEL SPOILING IN COOS BAY, OREGON

(*b*) Navigation Division, Dept. of the Army, Portland District, Corps of Engineers, Division of Environmental Systems and Resources, Research Applications Directorate, National Science Foundation.

(*e*) Study of actual chemical, physical and biological effects associated with the dredging and disposal methods of a hopper dredge. Field investigations and subsequent laboratory analyses were organized to evaluate the nature and magnitude of environmental changes resulting from dredging activities on October 4, 1972 at Coos Bay, Oregon. Methods and evaluation techniques for proper assessment are discussed and post-dredging conditions compared with a predredging baseline.

(*f*) Complete, July 1973.

(*g*) The physical, chemical and biological sampling techniques employed were found to be quite useful for describing acute effects of dredge spoil distribution and estuarine impacts, but more efficient techniques are needed to gain spatial and temporal resolution of chronic, long-term effects.

(*h*) **Effects of Hopper Dredging and In-Channel Spoiling (October 4, 1972) in Coos Bay, Oregon,** L. S. Slotta, C. K. Sollitt, D. A. Bella, D. H. Hancock, J. E. McCauley, R. Parr, 133 pages, 1973, $4.50.

128-09772-400-70

PHYSICAL CHARACTERISTICS OF THE YOUNGS BAY ESTUARINE ENVIRONS

(*b*) ALUMAX Pacific Aluminum Corporation.

(*e*) Primary research objectives of the physical baseline study were: 1) to determine the seasonal variation of the physical parameters (water quality, tidal fluctuations, and streamflows) affecting Youngs Bay, 2) to determine the flushing rate of Youngs Bay, 3) to investigate the circulation patterns in Youngs Bay, and the possible effect of different flow rates of the Columbia River upon circulation patterns, 4) to attempt to characterize basic sediment properties and patterns of movement and deposition for the Youngs Bay system. Resulting baseline information would have useful potential for assessing industrial impacts to estuarine environments near Youngs Bay.

(*f*) Report complete, May 1975.

(*g*) Tidal flushing predictions using Ketchums Modified Tidal Prism Method were made for Youngs Bay and the rivers entering the Bay, as well as the Skipanon River. Fluoride concentrations which would result from the proposed ALUMAX plant based on 0.25 lb. fluoride released per ton of aluminum produced were made.

The highest estimates of fluoride concentrations were associated with the low flows of the Skipanon River where summer time fluoride estimates range from 1.0 to 60 ppm depending on runoff conditions, while winter time estimates were of the order of 0.01 ppm fluoride increase. (Recent measured values for the Skipanon ranged from .03 to .06 ppm fluoride in the winter, to .45 ppm during the late fall.) In the Lewis and Clark and Youngs Rivers, fluoride levels would increase significantly over present ambient levels only when considering the worst probable case (100 days of fluoride terrestrial deposition, suddenly introduced to the river with drainage runoff). Youngs Bay proper is extremely well-flushed, and even under the worst probable conditions, increased fluoride concentrations would add only fractionally to the natural fluoride concentrations now present.

The report presents inventory baseline data and associated interpretations about the physical characteristics of the Youngs Bay (Oregon) estuarine environs. This is one of four volumes of the 1975 final report "Physical, Chemical and Biological Studies of Youngs Bay," prepared for the ALUMAX Pacific Aluminum Corporation.

(*h*) **Physical Characteristics of the Youngs Bay Estuarine Environs,** submitted to ALUMAX Pacific Aluminum Corporation by Ocean Engineering Programs, School of Engineering, Oreg. State Univ., Corvallis, Oreg., 310 pages, May 1975, $6.00.

PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Aerospace Engineering, University Park, Pa. 16802. Dr. Barnes W. McCormick, Department Head.

129-08218-120-20

COMPUTATION OF VISCOELASTIC FLOW

(*b*) Fluid Dynamics Program, Office of Naval Research (with partial support of Applied Research Laboratory).

(*c*) John L. Lumley.

(*d*) Basic research, computational, Doctoral thesis.

(*e*) Development of a stable computational scheme for the Oldroyd equations; computation of two one-dimensional flows.

129-08221-010-00

INVESTIGATION OF THE VISCOUS SUBLAYER

(*c*) John L. Lumley.

(*d*) Experimental, basic research.

(*e*) Extension of the work of Bakewell to measurement of space-time correlations among all components in the viscous sublayer, and extraction of three-dimensional space-time eigenvalue from the correlation measurements.

129-08915-120-20

POLYMER EXTENSION MEASUREMENTS

(*b*) Office of Naval Research, Fluid Dynamics Branch.

(*c*) John L. Lumley.

(*d*) Experimental; basic; Master's thesis.

(*e*) Streamwise extension of polymer molecules is measured by light scattering in a two-dimensional pure straining flow.

PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, Hydraulics Laboratory, University Park, Pa. 16802. Dr. Joseph R. Reed, Associate Professor.

130-07567-260-60

VERTICAL TRANSPORT OF COAL BY PIPELINE

(*b*) Pennsylvania Departments of Environmental Resources and Commerce.

(*d*) Analytical; developmental; Master's thesis.

(*e*) Two-phase upward transport has been studied in order to determine its economic advisability for deep mines. The hoisting of coal coupled with the dewatering of a mine of-

fers an attractive combination to analyze. Opinions with regard to feasibility are quite mixed in the literature. It is likely that feasibility is very conditional.

(*g*) A hydraulic hoisting system was designed and adapted conceptually to seven existing mines with conventional hoisting facilities. A capital cost comparison with conventional hoisting reveals that hydraulic hoisting would be favored in five of the mines. The device used in the design to feed minus 4 in. coal into a 10-12 in. pipeline was uncovered in the literature search and has only been model tested. The wide variety of conditions affecting such a comparison study is discussed in the report.

(*h*) **Feasibility Study of the Vertical Transport of Coal by Pipeline,** J. R. Reed, R. A. Hartman, *Special Research Rept. SR-97*, final report to sponsors, 95 pages, Sept. 30, 1973; information on availability through Coal Research Section, 527 Deike Bldg., University Park, Pa. 16802.
An Evaluation of Pipeline Transportation of Coal in Mines, J. R. Reed, R. A. Hartman, R. Stefanko, *Proc. 15th Ann. Mtg., Transportation Research Forum*, pp. 381-392, Oct. 1974.

130-08222-870-00

MODEL STUDY OF STORM SEWER EXIT BELOW AN OVERFLOW NAPPE

(*b*) College of Engineering Central Research Fund.
(*c*) Dr. Gert Aron, Assoc. Professor.
(*d*) Applied research; experimental.
(*e*) A model of an ogee overflow structure has been built and installed in a laboratory flume. A modeled storm sewer outlet emerges under the nappe of the overfall, thus using the characteristically low pressure at this point to increase the hydraulic gradient available in the sewer for full flow storm water conveyance. Experimentation will hopefully lead to the optimal location and angle of the sewer outlet.

130-08223-200-00

UNIFORM FLOW RESISTANCE IN OPEN CHANNELS

(*c*) Dr. J. R. Reed and Dr. Arthur C. Miller, Asst. Professor.
(*d*) Applied research; experimental; Master's thesis.
(*e*) Initially, the effect of shape on the Manning equation is being studied in a variable slope plywood flume utilized in an earlier project. A transition connects rectangular and trapezoidal sections of the flume and at any given time the two shapes have identical flows and slopes. Eventually, it is hoped that measured hot film turbulence levels will correlate with some resistance parameter for this flume as well as for rougher ones.
(*g*) Preliminary work reveals that the rectangular and trapezoidal sections have significantly different Manning n values at the same flow. Also, the Manning n value for the rectangular channel changes significantly as the flow changes.

130-08928-200-00

EVALUATION OF FRICTION SLOPE AVERAGING TECHNIQUES FOR VARIED CHANNEL FLOW

(*c*) Dr. J. R. Reed.
(*d*) Analytical; applied research; Master's thesis.
(*e*) Evaluate eight different energy gradient averaging techniques which are now used in direct step solutions of gradually varied flow profiles. Computer results of step computations in prismatic channels are to be compared against mathematically accurate solutions using numerical quadrature. Comparisons will be done for increasingly shorter steps in a given channel reach. Both S and M profiles will be analyzed.

130-08929-870-65

QUANTITATIVE AND QUALITATIVE IMPLICATIONS OF URBAN STORM RUNOFF ABATEMENT MEASURES

(*b*) The City of Philadelphia in cooperation with the Institute for Research on Land and Water Resources.
(*c*) Dr. Gert Aron, Dr. A. C. Miller, et al.
(*d*) Analytical field investigation; developmental; Master's thesis.
(*e*) Develop viable alternatives to the extremely expensive replacements and/or additions to storm sewer networks of insufficient capacity.

PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Mechanical Engineering, University Park, Pa. 16802. Dr. Donald R. Olson, Department Chairman.

131-08224-090-00

CONFINED SWIRLING FLOW

(*c*) Professor John A. Brighton.
(*d*) Experimental and analytical applied research; Ph.D. thesis.
(*e*) An analytical and experimental study of confined jet mixing with swirl is being carried out. The effects of swirl on mean flow and turbulence quantities is being examined for a swirling outer flow and a non-swirling jet; and a non-swirling outer flow and a swirling jet. The results provide a calculation method which may be used to assess the performance of devices involving swirling flows.
(*f*) Completed.
(*g*) Mixing of a turbulent jet with a coaxial slower-moving secondary stream in a constant diameter tube was investigated. Of special interest were the effects of swirling the jet and initial turbulence kinetic energy. The analysis involved a numerical solution of the governing flow equations which were simplified by the Prandtl boundary layer assumptions. The two unknown turbulent stresses in the flow equations were modeled by defining an isotropic effective viscosity. The effective viscosity was calculated from a two-equation model of turbulence. The turbulence model was modified for swirling flows.
Predicted results were compared with experimental results of several investigators. Good agreement was obtained when calculated results were compared with mean velocity and wall pressure data. The addition of swirl to the jet increased the rate of spread of the jet and resulted in decreasing the axial length required for mixing. The initial turbulence levels of the streams were found to have a significant effect on the distribution of mean velocity and pressure. This dependence has not been considered by most investigators.
(*h*) **The Prediction of Turbulent Confined Jet Mixing With and Without Swirl,** C. J. Hendricks, *Ph.D. Thesis*, Pa. State Univ., Mar. 1974.
The Effect of Swirl and Inlet Turbulence Kinetic Energy on Confined Jet Mixing, C. J. Hendricks, J. A. Brighton, *ASME J. Fluids Engrg.*, to be published.

131-08225-050-18

CHARACTERISTICS OF HIGH VELOCITY GASEOUS JETS SUBMERGED IN LIQUIDS

(*b*) Advanced Research Projects Agency, Dept. of Defense.
(*c*) Professor Gerald M. Faeth.
(*d*) Theoretical and experimental; M.S. and Ph.D. thesis research.
(*e*) Investigation considers the flow and transport characteristics resulting from the submerged injection of a high velocity gas into a liquid bath. Of particular interest are those cases where the gas stream is converted to a liquid within the bath. This includes the process of simple condensation of a vapor (e.g., steam-water); dissolving a gas into a liquid (e.g., ammonia-water); and the reaction of a gas with a liquid (e.g., oxidizer-liquid metal). The experimental measurements consider the entrainment characteristics of the jet; mean profiles of velocity, density, temperature, etc.; and the spreading and penetration distance of the gas in the liquid phase. The analysis of this process has employed the turbulent entrainment models of homogeneous free jet theory.

(*g*) Measurements of velocity and void fraction distributions in the noncondensing case have been completed. Penetration lengths have been measured for condensing systems at various pressures and for reacting systems involving molten salt-metal solutions with halogen oxidizers. Results correlate well with homogeneous entrainment theories when proper account of the large density variation in the two phase jet has been made. Current work is considering the buoyant flow regime.

(*h*) **Penetration of Vapor Jets Submerged in Subcooled Liquids,** J. W. Weimer, G. M. Faeth, D. R. Olson, *AIChE J.* **19**, 3, pp. 552-558, May 1973.
Combustion of a Submerged Gaseous Oxidizer Jet in a Liquid Metal, J. F. Avery, G. M. Faeth, *15th Symp. (Intl.) on Combustion*, in press.
Combustion of a Submerged Gaseous Oxidizer Jet in a Liquid Metal, J. F. Avery, *Ph.D. Thesis*, Pa. State Univ., 123 pages, Sept. 1974.
Characteristics of a Turbulent, Two-Phase, Submerged, Free Jet, S. R. Tross, *M.S. Thesis*, Pa. State Univ., 100 pages, Sept. 1974.

131-08930-630-50

UNSTEADY BLADE PRESSURES

(*b*) NASA, Lewis Research Center.
(*c*) Professor Robert E. Henderson.
(*d*) Experimental and theoretical; applied research, M.S. thesis.
(*e*) An instrumented blade is being developed to permit the measurement of unsteady pressure distribution on the rotor of an axial flow fan operated in a spatially varying inlet flow. A series of miniature pressure transducers are located along the blade chord to give the instantaneous pressure. The measurements will be compared with available unsteady cascade theories to demonstrate the effects of stagger angle, solidity and reduced frequency on the unsteady blade pressure distribution and lift.
(*g*) The design of the transducer mounting and experimental calibration of the transducer/cavity frequency response completed.

131-08931-060-70

WALL PLUMES

(*b*) Union Carbide Fellowship.
(*c*) Professor G. M. Faeth.
(*d*) Theoretical and experimental; M.S. and Ph.D. thesis research.
(*e*) The investigation considers the properties of turbulent thermal plumes flowing along a vertical wall. Parameters of interest include mean velocity and temperature profiles, turbulence quantities and heat transfer rates to the wall. Two-dimensional flow conditions are considered for both adiabatic and isothermal walls.
(*g*) Results to date have been confined to the adiabatic wall plume. For this case, profiles of mean velocity and temperature have been obtained and correlated by similarity analysis. This indicates higher velocities and temperatures for the wall plume, than for a comparable free plume. Present effort involves consideration of the isothermal wall case.
(*h*) **Fire Plume Next to a Vertical Wall,** J. J. Grella, *M.S. Thesis*, Pa. State Univ., 84 pages, Mar. 1974.

131-08932-140-18

INVESTIGATION OF A JET-INDUCED MIXING HEAT TRANSFER PROCESS

(*b*) Advanced Research Projects Agency, Dept. of Defense.
(*c*) Professors Kenneth K. Kuo and Gerard M. Faeth.
(*d*) Experimental and theoretical; applied research, M.S. thesis.
(*e*) Convective heat transfer coefficients for a jet-induced mixing process in a cylindrical chamber were measured. A heated fluid was injected centrally from one end of the chamber into a liquid bath. The injected fluid served to mix the bath causing an increase in heat transfer to the chamber walls. Both ends of the chamber were insulated so that only heat transfer through the side wall was considered. Data was obtained for two fluids, water and ethylene glycol, while varying different parameters such as injector size, fluid temperature, chamber geometry and jet momentum. An analysis assuming total jet momentum dissipation into shear stress along the chamber wall was developed using the Reynolds analogy to determine the characteristic parameters of the system. Good agreement between this analysis and the data was obtained.
(*f*) Completed.
(*g*) The experimental data was correlated in terms of an equivalent Stanton number and equivalent Reynolds number (both defined in terms of chamber geometry and jet momentum), Prandtl number and chamber length-to-diameter ratio. The study covered a range of Prandtl numbers from 3.4 to 123 and length-to-diameter ratios from 1.5 to 3.76.
(*h*) **Investigation of a Jet-Induced Mixing Heat Transfer Process,** F. X. Thomson, Jr., *M.S. Thesis*, Pa. State Univ., 96 pages, Aug. 1974.

PENNSYLVANIA STATE UNIVERSITY, Institute for Science and Engineering, Applied Research Laboratory, P. O. Box 30, University Park, Pa. 16801. J. C. Johnson, Laboratory Director.

132-03807-230-50

THERMODYNAMIC EFFECTS ON CAVITATION

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. J. William Holl.
(*d*) Experimental and theoretical.
(*e*) Investigations are carried out in the high speed cavitation tunnel employing various working fluids. At the present time, the primary fluid is Freon 113. Thermodynamic effects are investigated for both developed and limited cavitation over a range of temperatures and velocities. Analytical investigations are also being conducted.
(*h*) **Thermodynamic Effects on Developed Cavitation,** J. W. Holl, M. L. Billet, D. S. Weir, *ASME Cavity Flow Symp.*, May 1975.
Effect of Gas Diffusion on the Flow Coefficient for a Ventilated Cavity, M. L. Billet and D. S. Weir, *ASME Cavity Flow Symp.*, May 1975.

132-07569-230-21

CAVITATION INCEPTION CHARACTERISTICS OF REAL SURFACE ROUGHNESSES

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. J. William Holl; Dr. R. E. Arndt, 233-C Hammond Building.
(*d*) Experimental and theoretical.
(*e*) Problem concerns the cavitation characteristics of real surface roughness such as barnacles. Cavitation tests are to be conducted in a water tunnel and roughnesses are researched in the field.
(*h*) **The Influence of Surface Irregularities on Cavitation: A Collation and Analysis of New and Existing Data with Application to Design Problems,** J. C. Bohn, *M.S. Thesis*, Pa. State Univ., Dec. 1972.
Limited Cavitation on Surface Irregularities, R. E. A. Arndt, J. W. Holl, J. C. Bohn, W. Bechtel, *IAHR Symp.*, Rome, 1972.

132-08235-230-21

VORTEX CAVITATION

(*b*) Naval Ship Research and Development Center, Naval Sea Systems Command.
(*c*) Dr. J. William Holl; Dr. Roger E. A. Arndt; M. L. Billet.
(*d*) Experimental and theoretical.

(*e*) Study various forms of limited cavitation in vortex flows, i.e., vaporous and non-vaporous cavitation; noise characteristics; basic flow field.

(*h*) **Cavitation Research at the Garfield Thomas Water Tunnel,** J. W. Holl, R. E. A. Arndt, M. L. Billet, C. B. Baker, *Proc. Conf. on Cavitation*, Inst. Mech. Engr., Sept. 1974.

132-08236-230-22

THE EFFECT OF POLYMER ADDITIVES ON CAVITATION

(*b*) Naval Sea Systems Command.
(*c*) Dr. Roger E. A. Arndt; Dr. J. William Holl.
(*d*) Experimental and theoretical.
(*e*) Determine the effect of polymer additives on cavitation in a shear flow and on streamlined bodies.
(*h*) See 132-08235-230-21.

132-08916-230-22

SCALING LAWS FOR CAVITATION DAMAGE

(*b*) Applied Research Laboratory E&F Program, Naval Sea Systems Command.
(*c*) Dr. J. William Holl; Dr. R. E. A. Arndt.
(*d*) Experimental and theoretical.
(*e*) Problem concerns the determination of scaling laws for cavitation damage in a flow system. Initial tests are concerned with effect of velocity on cavitation damage on ogive nosed bodies.

132-08917-630-20

INVESTIGATION OF UNSTEADY FORCES AND MOMENTS ON AN AXIAL FLOW FAN ROTOR BLADE

(*b*) Office of Naval Research (Project SQUID), Naval Sea Systems Command.
(*c*) Mr. Edgar P. Bruce.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Measure and analyze the unsteady normal force and pitching moment on the mid-span segment of a blade of an axial flow fan rotor operating in a flow whose axial velocity component varies sinusoidally in the circumferential direction. The program variables are reduced frequency, blade space-to-chord ratio, blade stagger angle, and blade mean angle of attack. The experimental results will be used to provide design information and to assess the validity of available theoretical models.
(*g*) Test results are being reduced and analyzed.
(*h*) **Design and Evaluation of Screens to Produce Multi-Cylce Sinusoidal Velocity Profile,** E. P. Bruce, *AIAA Paper 74-623*, July 1974.
The ARL Axial Flow Research Fan, E. P. Bruce, *ASME Paper 74-FE-27*, May 1974.
Measurement and Analysis of Unsteady Normal Force and Pitching Moment, E. P. Bruce, *Proc. 2nd Interagency Symp. on Univ. Research in Transportation Noise*, North Carolina State Univ., June 1974.

132-08918-160-22

HUB VORTEX CAVITATION RADIATED SOUND

(*b*) Naval Sea Systems Command.
(*c*) Mr. Michael L. Billet and Mr. Donald E. Thompson.
(*d*) Experimental.
(*e*) Hub vortex cavitation was generated with a stationary set of blades mounted on a hub which terminated in a cone. Cavities of three different lengths were generated. For each cavity length, a hydrophone was traversed in discrete increments along its length. At each increment, the RMS value of the hydrophone output, bandpassed from 25 to 70 kHz, was measured and spectra were obtained. Two peaks in the hydrophone output, one above the cone tip and one above the end of the cavity were observed. Variation of hydrophone output with velocity for a constant length cavity was investigated also.

132-08919-550-22

PROPELLER TIME-DEPENDENT THRUST DUE TO TURBULENT INFLOW

(*b*) Naval Sea Systems Command.
(*c*) Mr. Donald E. Thompson.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Measurements of the time-dependent thrust generated by each of a series of propellers due to operation in various turbulent inflows have been made. The power spectra of the time-dependent thrust over a frequency range including blade passing frequency were made. Comparisons of the measured power spectra with those predicted by each of several analytical methods were made. It was shown that the broadband hump, centered at blade passing frequency, can be predicted and can be significant.
(*h*) **Time-Dependent Thrust Generated by a Propeller Operating in a Turbulent Inflow,** *Proc. 2nd Interagency Symp. on Univ. Research in Transportation Noise*, North Carolina State Univ., June 1974.

132-08920-160-21

RADIATED SOUND DUE TO ROTOR OPERATING IN A TURBULENT INFLOW

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. B. Lakshminarayana and Mr. Donald E. Thompson.
(*d*) Experimental and theoretical; applied research; M.S. thesis.
(*e*) Measurements were made of the radiated sound due to a ducted rotor operating in turbulent inflows with various length scales and intensities. Radiated sound spectra and directivity patterns were measured. Comparisons with predictions made with two different analytical methods were made. The parameters investigated include blade speed and flow coefficient. The current investigation centers on nonhomogeneous, nonisotropic turbulent inflows as produced by boundary layers, strut wakes, and secondary flows.
(*g*) The results for homogeneous, isotropic turbulence indicate a definite increase in the overall sound pressure level and an increase in the spectrum level of the sound pressure with an increase in turbulence intensity. For integral length scales smaller than the blade spacing, the total sound power is found to be proportional to (turbulence velocity/integral length)^2, where turbulence velocity is root mean square value normal to the blade chord. Comparison of theoretical results with experimental data indicates one theory to predict the sound pressure level fairly accurately in a limited frequency range. The results of this investigation are given in the reference below.
(*h*) **Turbulence Induced Noise in a Single Stage Axial Flow Fan,** B. E. Robbins, *M.S. Thesis*, Pa. State Univ., Aug. 1974.

132-08921-230-22

BLADE TIP CAVITATION AND ITS RADIATED SOUND

(*b*) Naval Sea Systems Command.
(*c*) Mr. Michael L. Billet and Mr. Donald E. Thompson.
(*d*) Experimental.
(*e*) The prediction of full-scale propeller cavitation performance and radiated noise from model tests is a major objective. Attempts have been made by McCormick to correlate tip vortex cavitation with Reynolds number, and this serves as a basis for this program to determine the radiated noise from a tip vortex. The radiated noise from a tip vortex will be measured in the 48-inch water tunnel for various amounts of cavitation. This will be done for a set of geometrically similar blades over a range of Reynolds numbers. Also, the effect of gas nuclei in the water on the radiated noise will be investigated.

132-08922-630-22

WOBBLE PLATE PUMP INVESTIGATION

(*b*) Naval Sea Systems Command.
(*c*) Walter S. Gearhart.

(*d*) Experimental and theoretical; applied research; M.S. thesis.

(*e*) The development of a pump configuration which is capable of pumping fluids with a high amount of suspended materials is being investigated. Efforts are directed at the use of a wobble plate impeller with centrifugal positioned hammers which will comminute the suspended solids as they pass through the pump. A series of wobble plate geometries are being tested to develop the empirical data to predict the overall performance of the pump. The ability of the pump to transport and grind solids in fluids typical of waste and sewage will be experimentally studied. A preliminary study of one configuration has been completed.

(*h*) **Experimental Evaluation of a Small Wobble Plate Pump,** W. S. Gearhart, *Internal Memo., File No. 72-134*, Applied Research Lab., Pa. State Univ., Aug. 1972.

132-08923-550-22

RESEARCH AND DEVELOPMENT OF PROPULSORS FOR SUBMERGED VEHICLES AND HIGH SPEED SURFACE SHIPS

(*b*) Naval Sea Systems Command.

(*c*) Dr. R. E. Henderson and Mr. W. S. Gearhart.

(*d*) Experimental and theoretical; basic and applied research.

(*e*) A continuing effort has been underway to develop propulsors having specific performance goals with respect to noise, cavitation resistance, weight and efficiency. Model fabrication and experimental evaluation of propulsor configurations consisting of single and contra-rotating propellers have been achieved. In addition, pumpjets of various configurations and geometries have been developed to provide exceptional cavitation resistance at high vehicle speeds. Integrated design of the propulsor and the vehicle stability and control systems is of primary concern. Experimental evaluation of numerous model designs has been performed in both the wind and water tunnel facilities located at ARL/PSU. Propulsor steady state performance, as well as propulsor cavitation characteristics, have been experimentally recorded while operating in a dilute polymer solution. The propulsor development effort has required a continued effort with respect to hydrodynamic blade design and axisymmetric flow field solutions.

(*h*) **The Design of Pumpjets for Hydrodynamic Propulsion,** E. P. Bruce, W. S. Gearhart, J. R. Ross, A. L. Treaster, *NASA SP 304*, 1974.

132-08924-550-22

ROTOR RESPONSE TO INLET DISTORTIONS

(*b*) Naval Sea Systems Command; NASA.

(*c*) Dr. R. E. Henderson.

(*d*) Experimental and theoretical; basic research; M.S. and Ph.D. thesis.

(*e*) The unsteady response of a rotating blade row to inlet velocity distortions is studied by investigation of the flow at the inlet and exit of the blades. By conducting surveys of the mean total pressure the unsteady circulation on the blades has been determined for various reduced frequency and blade solidities. These results are compared with theoretical predictions.

(*g*) The initial series of investigations indicate a significant effect of solidity at low values of reduced frequency on the unsteady response of a blade row. Theoretical analyses which include this effect are shown to predict the correct trends with varying solidity.

(*h*) **Theoretical Analysis of Fluctuating Lift on a Rotor,** R. E. Henderson, H. Daneshyar, *ARC R and M 3684*, 1972.

Unsteady Response of a Rotor to Upstream Disturbances, R. E. Henderson, *Ph.D. Thesis*, Cambridge Univ., Oct. 1972.

Unsteady Response of a Rotor from Measurements of Time-Mean Total Pressure, R. E. Henderson, *ASME Paper 73-GT-94*, Apr. 1973.

132-08925-250-22

THE EFFECT OF POLYMERS ON VEHICLE DRAG

(*b*) Naval Sea Systems Command.

(*c*) Mr. William R. Hall and Mr. Fred E. Smith.

(*d*) Experimental; applied research; design.

(*e*) The program involves the measurement of drag on models of various vehicle configurations with the vehicle operating in a "polymer ocean" or with various types and configuration ablative coatings.

(*g*) Results being analyzed.

132-08926-030-22

MEASUREMENT OF FORCES ON MODELS IN A WATER TUNNEL

(*b*) Naval Sea Systems Command and Sandia Laboratories.

(*c*) Mr. George Gurney and Mr. Fred E. Smith.

(*d*) Experimental; some basic and applied aspects.

(*e*) The program involves the measurement of body forces on various hydrodynamic configurations. Measurements were made over a range of velocities up to 73 ft/sec in non-cavitating flow. The drag changes due to the addition of appendages have been investigated. Forces on right circular cylinders of various end geometries and L/D ratios were obtained.

(*g*) Reports in preparation.

132-08927-030-22

TUNNEL WALL INTERFERENCE FOR BODIES OF REVOLUTION

(*b*) Naval Sea Systems Command.

(*c*) Mr. William R. Hall and Mr. Fred E. Smith.

(*d*) Experimental and theoretical.

(*e*) Body forces measured with large model-to-tunnel diameter ratio bodies require substantial corrections to predict vehicle performance under free-field condition. This investigation is intended to develop better corrections for various model configurations.

(*g*) A simplified slender body theory correction was developed and compared with two more sophisticated correction theories. Experimental verification of the three theories was made.

(*h*) **Tunnel Wall Interference for Bodies of Revolution in Non-Steady Motion,** W. R. Hall, *Appl. Res. Lab. Unclassified TM 73-224*, Aug. 1973.

PHYSICAL DYNAMICS, INCORPORATED, P. O. Box 1069, Berkeley, Calif. 94701. Dr. J. Alex Thomson, Vice President and Principal Investigator.

133-08933-420-18

OCEAN WAVE SPECTRAL STUDIES

(*b*) Defense Advanced Research Projects Agency.

(*c*) Dr. Bruce J. West, Staff Scientist.

(*d*) Theoretical applied research.

(*e*) The evolution of the wave spectrum at the surface of the ocean is described by means of a spectral transfer equation. Both a fundamental approach using a system of non-linear eigenmode equations, in conjunction with the "molecular chaos" assumption of Boltzmann, and heuristic modeling of strongly non-linear effects, e.g., wavebreaking, have been used in the development of this description. The coupling of the surface wave field to the internal wave field has been investigated and the dynamics of the internal waves described using a Hamiltonian model of the interaction.

(*g*) The spectral transfer description of the evolving wave spectrum on the ocean surface is consistent with oceanographic data. Oceanographic internal waves are generated by the resonant interaction of surface gravity waves. The surface waves interact in a narrow angular interval ($\approx 5°$) and generate internal waves at approximately 90° to their direction of propagation.

(*h*) **Mode Coupling Description of Ocean Wave Dynamics,** B. J. West, K. M. Watson, J. A. Thomson, *Phys. Fluids* **17**, 6, pp. 1059-1067, June 1974.
A Transport Equation Description of Nonlinear Ocean Surface Wave Interactions, K. M. Watson, B. J. West, to appear in *J. Fluid Mech.*
Statistical Mechanics of Ocean Waves, B. J. West, J. A. L. Thomson, K. M. Watson, to appear in *J. Hydronautics.*
Note Concerning the Correlations in Space and Time of Surface Wave Amplitudes, K. M. Watson, B. J. West, submitted to *J. Geophysical Research.*
Interaction of Small Amplitude Surface Gravity Waves with Surface Currents, J. A. Thomson, B. J. West, to appear in *J. Phys. Oceanography.*
Reports (obtainable from Defense Documentation Center):
Interaction of Non-Saturated Surface Gravity Waves with Internal Waves, J. A. Thomson, B. J. West, *RADC-TR-72-280, PD 72-023*, Oct. 1972.
A Spectral Transfer Model of Ocean Wave Spectra: I. Formulation, J. A. Thomson, B. J. West, *RADC-TR-192, PD 72-029*, May 1973.
Energy Spectra of The Ocean Surface: II. Interaction with Surface Current, B. J. West, K. M. Watson, B. J. Cohen, *RADC-TR-74-15, PD 73-037*, Oct. 1973.
Energy Spectra of The Ocean Surface: III. Modulation by a Surface Current, K. M. Case, K. M. Watson, B. J. West, *RADC-TR-74-110, PD 73-047*, Dec. 1973.
A Transport Equation Description of Non-Linear Ocean Surface Wave Interactions, K. M. Watson, B. J. West, *RADC-TR-74-116, PD 73-048*, Jan. 1974.
Scattering of Electromagnetic Waves From the Two-Dimensional Ocean Surface: I. Linear Waves in the Presence of Current, K. M. Watson, B. J. West, *RADC-TR-74-42, PD 73-050*, Jan. 1974.
Statistical Mechanics of Ocean Waves, B. J. West, J. A. Thomson, K. M. Watson, *RADC-TR-74-41, PD 73-051*, Dec. 1973.
Note Concerning the Correlations in Space and Time of Surface Wave Amplitudes, K. M. Watson, B. J. West, *RADC-TR-74-267, PD 74-064*, July 1974.

UNIVERSITY OF PITTSBURGH, School of Engineering, Chemical and Petroleum Engineering Department, Pittsburgh, Pa. 15261. Dr. George E. Klinzing, Associate Professor and Graduate Coordinator.

134-08238-000-00

LAMINAR FLOW INSTABILITY IN PARALLEL CONVECTION COUPLED CHANNELS

(*d*) Theoretical; basic and applied research; Doctoral thesis.
(*f*) Completed.
(*g*) Parametric results are presented for a range of heat flux, flow rate, and fluid state conditions. Results show that the inlet temperature and the inlet and outlet orifices can change the flow rate at the point of neutral stability by up to an order of magnitude. Time constants for the single channel flow excursion are strongly dependent on inlet temperature; they range from minutes at cryogenic inlet temperatures to hours at ambient inlet temperature.
A derivation for the stability criteria for two parallel channels with interchannel heat exchange is given. The linearized solution for constant total flow always yields stable behavior. The constant pressure drop solution may be unstable depending on the sign of the pressure drop-flow rate derivative. A comparison of the transient single channel and two channel solutions shows that the flow rate in the two channel model is always greater than the single channel model.
The closed form solution results are confirmed by comparison with a multidimensional numerical analysis. A program was developed with implicit numerical techniques, decoupling the solid and fluid equations by iterating on the interface boundary condition. This technique is verified by comparison with available test data. A nine channel model reacted similarly to the two channel model but with an added time delay. The numerically calculated growth rate agreed within 10 percent of that calculated by the closed form solution.
(*h*) *GVC/AIChE – Joint Meeting, Paper G2*, Munich, Sept. 1974.

134-08934-290-00

EXPERIMENTALLY DETERMINED EFFECT OF ARTIFICIALLY ROUGHENED SURFACES ON HYDRAULIC LOSS COEFFICIENTS

(*d*) Experimental, applied.
(*g*) Experimental data were obtained for the flow of water between a "smooth" and an artificially roughened plate for the purpose of determining the effect of artificially roughened surfaces of moderate to large relative roughness (i.e., $0.04 < \epsilon/DE < 1.05$) on hydraulic loss coefficients.
The experiment was designed to obtain data for various depths and widths of square-tooth and sawtooth shaped serrations for flow gaps of 0.012, 0.030 and 0.050 inches between the "smooth" and artificially roughened plates with pressure differentials ranging from 20 to 130 psi.
The reduced experimental data indicates that artificially roughened surfaces significantly increase the hydraulic loss coefficient which results in decreased flow rates between two parallel plates.
Comparison of the experimental data to various empirical correlations used for the prediction of frictional and form loss coefficients do not adequately correlate the experimental data.
Based on observations, the experimental data can be correlated to various physical dimensions of the test plate configuration. Depending on the shape of the serrations and the flow gap between the plates, however, the correlating parameters vary due to the presence of differing flow phenomena.

UNIVERSITY OF PITTSBURGH, Department of Civil Engineering, Water Resources Program, Pittsburgh, Pa. 15261. Professor Chao-Lin Chiu, Program Chairman.

135-08240-810-54

STOCHASTIC HYDROLOGIC SYSTEMS

(*b*) National Science Foundation.
(*c*) Dr. Rafael G. Quimpo.
(*d*) Theoretical with field investigation and data analysis.
(*e*) Stochastic models of hydrologic systems are investigated with a view of unifying their formulation under a common framework with models of parametric hydrology.
(*h*) **Link Between Stochastic and Parametric Hydrology,** *J. Hydraul. Div., ASCE* **99**, HY3, 1973.
On the Variability of Seasonal Parameters in Hydrologic Time Series, R. G. Quimpo, M. S. Cheng, *J. Hydrology* **23**, pp. 279-287, Amsterdam, Netherlands, 1974.

135-08935-300-54

SECONDARY CURRENTS IN NATURAL STREAMS AND RIVERS

(*b*) National Science Foundation.
(*d*) Analytical, with field data.
(*e*) Develop a technique and procedure for computing secondary currents in natural streams and rivers, and use the technique to study the characteristics, development, and

sensitivity of secondary currents to various factors affecting them.

PURDUE UNIVERSITY, School of Aeronautics and Astronautics, West Lafayette, Ind. 47907. Bruce A. Reese, Head.

136-08942-020-50

ACOUSTICAL THEORY OF TURBULENCE

(*b*) NASA Research Grant.
(*c*) Professor C. P. Kentzer.
(*d*) Theoretical, basic research.
(*e*) Study processes of generation, transmission, and absorption of noise in turbulent flows. Various modes of wave propagation are separated and identified as acoustic, entropy and vorticity modes. Statistical treatment of wave interactions in presence of high gradients is studied with the objective of proposing mathematical models of noise-turbulence interactions.
(*g*) Wave representation of turbulence was shown to be mathematically equivalent to quantum theory. A quantum-like formalism of the theory leads to turbulent principles of uncertainty, correspondence, and complementarity and to conditions for quantization of phase. Methods of derivation of Schroedinger-type equations for Fourier transforms of wave amplitude distribution functions were formalized.
(*h*) **Acoustical Theory of Turbulence,** C. P. Kentzer, *Archives Mech.* **26**, 5. pp. 805–816. 1974.
Acoustical Theory of Turbulence, C. P. Kentzer, *Proc. 2nd Interagency Symp. on University Research in Transportation Noise* **1**, pp. 128-144, N. C. State Univ., Raleigh, N. C., June 5-7, 1974.
Isomorphism of Statistical Turbulence and Quantum Theory, C. P. Kentzer, *50th Ann. Mtg. Indiana Acad. Sci.*, DePauw Univ., Greencastle, Ind., Nov. 1, 1974 (copies available from the author).
Amplification, Attenuation, and Dispersion of Sound in Inhomogeneous Flows, C. P. Kentzer, presented *89th Mtg. ASA*, Austin, Tex., Apr. 1975 (copies available from the author).

PURDUE UNIVERSITY, Department of Agricultural Engineering, West Lafayette, Ind. 47907. Dr. G. W. Isaacs, Department Head.

137-03808-830-05

PREDICTING RUNOFF AND GROSS EROSION FROM FARMLAND AND DISTURBED AREAS (also see **Agri. Research Serv., North Central Region, Project 04275**).

(*b*) Agricultural Research Service, USDA; Agricultural Experiment Station, Purdue University.
(*c*) Mr. Walter H. Wischmeier.
(*d*) Experimental; development.
(*e*) The relationships of rainfall, soil, topographic, land-use, and management parameters to runoff and soil erosion are evaluated from field-plot and laboratory data, and the mechanics of soil erosion by water are studied as a basis for mathematically simulating the soil erosion process.
(*g*) Further progress was made on development of a soil loss equation derived from basic principles of sediment transport, hydraulics and erosion mechanics and capable of predicting individual-storm events, but the equation is not ready for field use. Application of modeling principles improved and extended the utility of the universal soil loss equation. A procedure was developed for predicting topographic effect on soil detachment when slopes are irregular in shape. First-approximations of the relations of surface-condition parameters to erosion-control effectiveness of conservation tillage practices were derived from plot data obtained with simulated rainfall. Temporal and spatial variations in velocity, depth and shear stress of flow in a rill were studied in the laboratory.
(*h*) **The Overland Flow Process Under Natural Conditions,** G. R. Foster, *Proc. 3rd Intl. Seminar for Hydrology Professors*, Dept. of Agric. Engrg., Purdue Univ., West Lafayette, Ind., pp. 173-185, 1974.
Evaluating Irregular Slopes for Soil Loss Prediction, G. R. Foster, W. H. Wischmeier, *Trans. Amer. Soc. Agric. Engrs.* **17**, 2, pp. 305-309, 1974.
Stage Recorder with Direct Float-To-Pen Linkage, L. D. Meyer, G. R. Foster, *Trans. Amer. Soc. Agric. Engrs.* 17, 4, pp. 666-667, 1974.
The Influence of Vegetation and Vegetative Mulches on Soil Erosion, L. D. Meyer, J. V. Mannering, *Proc. 3rd Intl. Seminar for Hydrology Professors*, Dept. of Agric. Engrg., Purdue Univ., West Lafayette, Ind., pp. 355-366, 1974.
Phosphorus Relationships in Runoff From Fertilized Soils, M. J. M. Romkens, D. W. Nelson, *J. Environmental Quality* 3, 1, pp. 10-13, 1974.

137-07584-820-61

IMPROVING THE QUALITY OF LAND AND WATER RESOURCES

(*b*) Agricultural Experiment Station, Purdue University; Environmental Protection Agency; Office of Water Research and Technology, USDI.
(*c*) Dr. E. J. Monke.
(*d*) Experimental, theoretical, field investigation, applied research.
(*e*) Study the dynamics of water and pollutant movement in soil, to evaluate the effects of subsurface drainage on crop production, to evaluate erosion and related chemical transport from agricultural soils, and to simulate the effects of land use on sedimentation and related-pollution of streams and lakes.
(*g*) Research has been completed on the movement of pollutant phosphorus in unsaturated soil. Also a laboratory study on erosion and related chemical transport from some relatively flat agricultural soils has been finalized. Present efforts are being directed toward simulation of the effects of land use on sedimentation and related-pollution of our water resources.
(*h*) **Some Effects of Soil and Ambient Air Temperature Differences on Tomato Growth,** E. J. Monke, R. M. Alverson, *Proc. Ind. Acad. Sci.* **81**, pp. 330-337, 1972.
Experimental Evaluation of a Method for Determining Unsaturated Hydraulic Conductivity, R. W. Skaggs, E. J. Monke, L. F. Huggins, *Trans. Amer. Soc. Agric. Engrs.* **16**, 1, pp. 85-88, 1973.
Biological Effects in the Hydrological Cycle, E. J. Monke, (ed.), *Proc. 3rd Intl. Seminar for Hydrology Professors*, Agric. Exp. Sta., Purdue Univ., 391 pages, July 18-30, 1971.
A Laboratory Study of Soil Loss, Water Loss and Physical-Chemical Composition of Eroded Materials from Three Maumee River Basin Associated Soils, H. J. Marelli, *M.S. Thesis*, Purdue Univ., 1974.
Adsorption of Phosphorus By Unsaturated Synthetic Soil, E. D. Millette, *Ph.D. Thesis*, Purdue Univ., 1974.

137-07585-810-33

CHARACTERIZATION OF THE HYDROLOGY OF SMALL WATERSHEDS

(*b*) Agricultural Experiment Station, Purdue University; Office of Water Research and Technology, USDI.
(*c*) Dr. L. F. Huggins.
(*d*) Experimental, basic, applied, design.
(*e*) Develop an analytical method to accurately describe the hydrologic response of natural watersheds to real or hypothetical storms independent of gaged records for a watershed.
(*g*) Present efforts are being directed toward improving the characterization of overland flow processes and toward the development of more efficient computer programs to implement the model for watersheds up to 10 sq. mi. in size.

(*h*) **Hydraulics of Shallow Flows Over Stable Eroded Sand Surfaces Defined By Area Spectra,** J. R. Burney, L. F. Huggins, *Tech. Rept. 36*, Water Resour. Res. Center, Purdue Univ., Feb. 1973.
Simulation of the Hydrology of Ungaged Watersheds, L. F. Huggins, J. R. Burney, P. S. Kundu, E. J. Monke, *Tech. Rept. 38*, Water Resour. Res. Center, Purdue Univ., Feb. 1973.

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PURDUE UNIVERSITY, Department of Agronomy, West Lafayette, Ind. 47907. Dr. M. W. Phillips, Department Head.

138-0124W-810-00

DYNAMICS OF WATER INFILTRATION INTO SOIL AS GOVERNED BY SURFACE CRUSTING AND SEALING

(*e*) For summary, see Water Resources Research Catalog **8,** 2.0606.
(*f*) Completed.
(*g*) One-dimensional, horizontal soil-water absorption through a thin but resistive inlet zone of soil was studied theoretically and experimentally. An exact numerical solution was obtained, and also an approximate solution based on similarity reduction that held with good accuracy for early to intermediate times of flow, for experimental data collected for two different soils. Also, the principle of dual-energy gamma-ray attenuation was successfully developed for measuring both water and soil content in swelling soils. The dual-energy gamma-ray beam was produced by a 280-mCi source of ^{137}Cs placed behind a 389-mCi source of ^{241}Am, all in lead shields and collimators. Single-detector separation of the count intensities from ^{137}Cs and ^{241}Am was achieved by a straightforward calibration. The resulting nondestructive measurements were relatively precise and rapid. For a highly swelling mixture of equal parts bentonite and silt initially air dry in a confined column, the bulk density decreased by half at the column end where water was admitted. The resulting expansion caused a compensating compression in the remaining dry portion of the column. The transient water contents and bulk densities conformed to a definite pattern in keeping with the theory of water flow in swelling porous media.
(*h*) **Water and Soil Behavior Under Transiently Wetting Conditions,** D. L. Nofziger, *Ph.D. Thesis*, Purdue Univ. Library, June 1972.
Experimental Curves and Rates of Change from Piecewise Parabolic Fits, P. C. DuChateau, D. L. Nofziger, L. A. Ahuja, D. Swartzendruber, *Agron. J.* **64,** 1, pp. 538-542, 1972.
Crusting and Swelling Effects on Water Infiltration Into Soil, D. L. Nofziger, D. Swartzendruber, L. R. Ahuja, *Tech. Rept. 28*, Purdue Univ., Water Resour. Res. Center, West Lafayette, Ind., 90 pages, Jan. 1973.
Horizontal Soil-Water Intake Through a Thin Zone of Reduced Permeability, L. R. Ahuja, D. Swartzendruber, *J. Hydrol.* **19,** 1, pp. 71-89, 1973.
Flux-Gradient Relationships and Soil-Water Diffusivity from Curves of Water Content Versus Time, D. L. Nofziger, L. R. Ahuja, D. Swartzendruber, *Soil Sci. Soc. Amer. Proc.* **38,** 1, pp. 17-23, 1974.
Material Content of Binary Physical Mixtures As Measured With a Dual-Energy Beam of Gamma Rays, D. L. Nofziger, D. Swartzendruber, *J. Appl. Phys.* **45,** 12, pp. 5443-5449, 1974.

138-07586-810-33

MOVEMENT AND RETENTION OF WATER IN SOILS AND POROUS MEDIA

(*e*) For summary, see Water Resources Research Catalog **9,** 2.0516.
(*f*) Completed.
(*g*) Saturated-flow experiments were conducted on mixtures of 5, 10, and 15 percent bentonite in fine quartz sand, involving 1.0 N calcium chloride solution followed by successively more dilute solutions containing increasing relative amounts of sodium chloride. Permeability distributions, ionic components, and suspended clay content of the liquid effluent were measured. Definite patterns in permeability reduction and liquid transport of clay particles were found in response to increased sodium and reduced ionic concentrations. Though the phenomenon is very complex, insight is provided on the soil response to waters of varying ionic quality. In another study, infiltration and runoff under constant rainfall were treated by approximate theory, using the Green and Ampt approach. The resulting equations could be well-expressed by even simpler functions of time. For describing runoff from a small infiltrometer plot in the field, a simple overflow model was devised which is particularly applicable when the classic Horton equation can be used to describe the infiltration process.
(*h*) **Effect of Portland Cement on Soil Aggregation and Hydraulic Properties,** L. R. Ahuja, D. Swartzendruber, *Soil Sci.* **114,** 5, pp. 359-366, 1972.
The Physics of Infiltration, D. Swartzendruber, D. Hillel, *Ecological Studies 4 (Physical Aspects of Soil Water and Salts in Ecosystems)*, pp. 3-15, Springer-Verlag, Heidelberg, 1973.
Streaming-Potential Effects in Saturated Water Flow Through a Sand-Kaolinite Mixture, S. Gairon, D. Swartzendruber, *Ecological Studies 4 (Physical Aspects of Soil Water and Salts in Ecosystems)*, pp. 141-151, Springer-Verlag, Heidelberg, 1973.
Controlled Instantaneous Application of Free Water to a Porous Surface, D. Swartzendruber, M. S. Asseed, *Soil Sci. Soc. Amer. Proc.* **37,** 6, pp. 967-968, 1973.
A Comparison of Physically-Based Infiltration Equations, D. Swartzendruber, E. G. Youngs, *Soil Sci.* **117,** 3, pp. 165-167, 1974.

138-08936-810-33

WATER MOVEMENT IN RIGID AND SWELLING SOILS

(*b*) Purdue Univ. Agricultural Experiment Station, and Office of Water Research and Technology.
(*c*) Dr. Dale Swartzendruber.
(*d*) Experimental and theoretical; basic and applied research; for Master's and Doctoral theses.
(*e*) Water transport through rigid and swelling soils and porous media is being studied under both saturated and unsaturated conditions, to enable better quantification of the soil-water phase of the hydrologic cycle. Infiltration from constant-flux rainfall will be considered, as will the entry of suspensions (clay or sewage sludge) into porous media. Dual-energy gamma-ray attenuation will be used in measurements of both swelling soils and the distribution of infiltrated suspension solids within porous media and soils.
(*g*) Simplified runoff equations, derived from flow theory for infiltration into rigid soils from constant-flux rainfall, were fitted by least squares to runoff data accumulated in Indiana with the Purdue small-plot sprinkling infiltrometer. One of the fitted constants was the near-saturated soil hydraulic conductivity, a difficult parameter to measure for surface soils in the field. In another study, columns of bentonite suspension were compressed by air-pressure loading. Cumulative water outflow was precisely proportional to the square root of time for a very considerable period. The distribution of clay in the columns was monitored over time with single- and dual-energy gamma-ray attenuation.
(*h*) **Infiltration of Constant-Flux Rainfall Into Soil As Analyzed By the Approach of Green and Ampt,** D. Swartzendruber, *Soil Sci.* **117,** 5, pp. 272-281, 1974.

138-08937-870-33

ENTRY OF SEWAGE SLUDGE AND EFFLUENT INTO SOIL AND THEIR EFFECTS ON SOIL HYDROLOGY

(*b*) Office of Water Research and Technology.

(c) Dr. Dale Swartzendruber.
(d) Experimental and theoretical; basic research; for Master's and Doctoral theses.
(e) The movement of heterogeneous fluids into and through sands and soils will be studied, using clay suspensions or sewage effluent as the fluids. Effects on porous-medium permeability and other liquid-flow properties will be determined, and the accumulation of solids within the sand or soil will be measured as a function of time and position by dual-energy gamma-ray attenuation. The purpose of the study is to provide a better understanding of the hydrologic effects of disposing of sewage effluent on land.
(g) Preliminary results for bentonite-clay suspensions applied to initially dry sand indicate that very profound reductions in the rate of fluid intake can occur rather soon after the application of the suspension.

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PURDUE UNIVERSITY, School of Chemical Engineering, West Lafayette, Ind. 47907. Professor Lowell B. Koppel, Head.

139-06781-070-54

FLOW REGIMES AND FLOW THROUGH POROUS MEDIA

(b) National Science Foundation.
(c) Professor R. A. Greenkorn.
(d) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(e) Determine theroretically and experimentally the flow regimes and their dynamical range for flow in porous media. A creeping flow regime (Darcy's law is valid) is usually assumed for flow in porous media. However, it may be owing to pressure transients or changes in properties of the bed that other flow regimes are present. A first approach to determine flow regimes might be to study the response of fluid-filled packed beds to pressure oscillations. Theoretical models such as the wave equation for a viscous fluid in porous media might be used to determine possible regimes.
(h) **A Theory of the Transient Response of Rigid Porous Media,** P. G. Smith, R. A. Greenkorn, R. G. Barile, *J. Acoust. Soc. Am.* **56**, 3, p. 781, 1974.
Infrasonic Response Characteristics of Gas and Liquid-Filled Porous Media, P. G. Smith, R. A. Greenkorn, R. G. Barile, *J. Acoust. Soc. Am.* **56**, 3, p. 789, 1974.

139-06783-070-54

DISPERSION DURING FLOW IN NON-UNIFORM, HETEROGENEOUS, ANISOTROPIC POROUS MEDIA

(b) National Science Foundation.
(c) Professor R. A. Greenkorn.
(d) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(e) To relate the dispersion tensor to properties of the porous media. We have measured dispersion in heterogeneous linear models and are presently engaged in measuring the effect of non-uniformity and anisotropy on dispersion. These measurements will be made in linear and radial glass bead models. Once the measurements are complete we will relate these data to continuous and statistical theories of the media.
(h) **Dispersion and Adsorption in Porous Media,** S. P. Gupta, *Ph.D. Thesis*, available Purdue Univ. Library.
Dispersion During Flow with Bilinear Adsorption, S. P. Gupta, R. A. Greenkorn, *Water Resour. Res.* **9**, 5, p. 137, 1973.
Determination of Dispersion and Nonlinear Adsorption Parameters for Flow in Porous Media, S. P. Gupta, R. A. Greenkorn, *Water Resour. Res.* **10**, 4, p. 839, 1974.
Dispersion in Non-Uniform and Anisotropic Porous Media, M. B. Moranville, *Ph.D. Thesis*, available Purdue Univ. Library.
A Study of Dispersion in a Stochastic Model of a Non-Uniform Porous Media, M. B. Moranville, D. P. Kessler, R. A. Greenkorn, *Proc. RILEM/IUPAC Intl. Symp. Pore Structure and Properties of Materials*, Prague, p. A-93, 1973.

139-07592-130-00

DRAG REDUCTION IN TWO-PHASE FLOW

(c) Professor R. A. Greenkorn or Asst. Professor D. P. Kessler.
(d) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(e) To measure and correlate drag coefficients in tubes, fittings, pumps, etc., in the laminar, transitional, and turbulent regimes for the annular flow of two liquids plus a suspended solid phase. The outer liquid will be viscoelastic. Experiments will be run in flow slip at Reynolds number up to 100,000. Pressure drop measurements, velocity profiles, and visual observations will be used to postulate mechanisms for such flow and derive predicting equations. The data will be correlated according to these equations.
(h) **A Study of Liquid-Liquid Flow in Pipes,** W. P. Garten, *M.S. Thesis*, available Purdue Univ. Library.
A Study of Annular Two-Phase Oil-Water Flow in Conduits, M. H. Stein, *M.S. Thesis*, available Purdue Univ. Library.

139-08242-020-00

STATISTICAL AND PHENOMENOLOGICAL MODELS OF TURBULENT ENERGY EQUATION

(c) R. N. Houze, Assoc. Professor.
(d) Theoretical; basic.
(e) Solutions of the turbulent energy equation are being obtained utilizing various statistical and phenomenological models for the turbulent stresses. Solutions are being compared with available published data. Methods are to be extended to free surface flows, with aim of predicting turbulence characteristics pertinent to interphase transport processes.

139-08243-130-00

FREE BOUNDARY TURBULENCE

(b) National Science Foundation.
(c) Assoc. Professors R. N. Houze, T. G. Theofanous.
(d) Experimental, theoretical, basic; M. S. and Ph.D. theses.
(e) A two-dimensional fully developed, stratified, gas liquid flow system is being studied with special emphasis on the turbulent characteristics of the liquid phase in the immediate vicinity of the interface.
(h) **Turbulent Characteristics of Two-Phase, Gas-Liquid, Stratified Channel Flow,** D. M. Johns, T. G. Theofanous, R. N. Houze, *Proc. Symp. on Turbulence in Liquids*, Rolla, Mo., 1973.

139-08244-130-00

TURBULENT TRANSPORT AT FREE INTERFACES

(c) Assoc. Professors R. N. House, T. G. Theofanous.
(d) Experimental, theoretical, basic; Ph.D. theses.
(e) Statistical and eddy turbulence models are being devised to elucidate the mechanism of the fluid mechanical interaction of bulk turbulence and a free interface and hence arrive to a quantitative description of the mass transfer characteristics of the interface.
(h) **On Predicting Mass Transfer at Turbulent Free Interfaces With a Large Eddy Model,** L. K. Brumfield, *M.S. Thesis*, available Purdue Univ. Library.

139-08245-120-00

RHEOLOGICAL PROPERTIES OF VISCOELASTIC POLYMERS

(b) Purdue Research Foundation.
(c) Professor Roger E. Eckert.
(d) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(e) Obtain fundamental properties of viscoelastic polymers through the industrially and fundamentally important high shear rate regions. These basic rheological properties are

evaluated throughout a very wide range of shear rates by studying continuous flow through a channel approximating infinite parallel plates. This seldom explored geometry for the flow channel has now been found to have important advantages in obtaining both shear and normal stress measurements. Pressure transducers are flush mounted at various distances down the channel to measure the force exerted by the fluid. The shear stress and the normal stress perpendicular to the plates are measured as functions of shear rate. This geometry enables us to measure the shear stress and the normal stress perpendicular to the plates at shear rates from 0.03 to 25,000 sec^{-1}, the upper value being limited only by the onset of turbulence in the particular dimensions used. Thrust measurements on the exiting fluid stream are taken to determine the normal stress in the direction of flow; it can be measured in a higher range of shear rate, 40,000 to 130,000 sec^{-1}. By combining these parallel plate data with measurements obtained on our Weissenberg Rheogoniometer this normal stress can also be extended to lower shear rates.

(*h*) **Rheological Properties of Polymers from Continuous Flow Through a Channel Approximating Infinite Parallel Plates,** E. J. Novotny, Jr., R. E. Eckert, *Trans. Soc. Rheol.* **18**, pp. 1-26, 1974.

Direct Measurement of Hole Error for Viscoelastic Fluids in Flow Between Infinite Parallel Plates, E. J. Novotny, Jr., R. E. Eckert, *Trans. Soc. Rheol.* 17:2, pp. 227-241, 1973.

Ribbed Flow From a Flat Channel, R. E. Eckert, E. J. Novotny, Jr., *Nature (Phys. Sci.)* **241**, pp. 147-148, 1973.

Rheological Properties of Polymers from Continuous Flow through a Channel Approximating Infinite Parallel Plates, E. J. Novotny, Jr., *Ph.D. Thesis*, available Purdue Univ. Library.

PURDUE UNIVERSITY, Great Lakes Coastal Research Laboratory, Department of Geosciences, Lafayette, Ind. 47907. Dr. William L. Wood, Laboratory Director; Dr. Gunnar Kullerud, Department Head.

141-08943-410-20

LONGSHORE CURRENT GENERATION AND PREDICTION

(*b*) Office of Naval Research.
(*c*) G. A. Meadows, Research Instructor.
(*d*) Theoretical and field experimental; basic and applied; Doctoral thesis.
(*e*) Research is focused at the two-dimensional prediction of a spatially and temporally fluctuating longshore current.
(*g*) Large and rapid velocity fluctuations are an inherent characteristic of the longshore current flow field. These fluctuations are of very short period, two to five seconds, and of amplitude comparable to the mean value of the longshore current itself.

141-08944-410-10

EFFECTIVENESS OF BEACH NOURISHMENT AND REVETMENT STRUCTURES

(*b*) U. S. Army, Corps of Engineers.
(*c*) W. L. Wood, Associate Professor.
(*d*) Field experimental investigation, applied; Masters and Doctoral theses.
(*e*) Measure and evaluate the degree of coastal stabilization achieved by beach nourishment and/or revetment structures along the southeastern end of Lake Michigan.

141-08945-420-20

SHORT CRESTED WAVE THEORY IN COASTAL HYDRODYNAMIC MODELS

(*b*) Office of Naval Research.
(*c*) W. L. Wood, Associate Professor.
(*d*) Theoretical and experimental, basic and applied.
(*e*) To develop coastal wave transformation relationships in three dimensions utilizing the assumption of short crested wave representation.
(*g*) Probability distributions along the crest of breaking waves have been shown to be significantly different from long crested wave expectations. Initial prediction of breaking wave distributions has been accomplished by finite wave crest element methods.
(*h*) **Wave Analysis System for the Breaker Zone,** W. L. Wood, *Proc. Intl. Symp. on Ocean Wave Measurement and Analysis* **1**, 1974.

PURDUE UNIVERSITY, School of Mechanical Engineering, Thermal Sciences and Propulsion Center, West Lafayette, Ind., 47907. Professor D. E. Abbott, Director.

142-08946-010-26

AN ANALYSIS OF TIME-DEPENDENT TURBULENT WALL LAYERS AND UNSTEADY SEPARATION IN NOMINALLY STEADY FLOW

(*b*) Mechanics Division, U. S. Air Force Office of Scientific Research.
(*c*) D. E. Abbott and J. D. A. Walker.
(*d*) Analytical, basic and developmental research.
(*e*) A new model of the viscous sublayer, in a turbulent boundary layer which is two-dimensional in the time-mean sense, is under investigation. The model is motivated by recent experimental evidence which suggests that the sublayer is a region which grows in thickness with time until eventually a burst occurs which ejects fluid outward from the wall and downstream. The sublayer then collapses and the process repeats almost periodically. The mathematical model of the instantaneous flow in the sublayer is based on this observed behavior. The purpose of the work is to develop a better understanding of turbulent wall layers and in particular to study the problem of turbulent separation.
(*g*) The mathematical equations considered have been shown to be an incontravertible consequence of the experimentally observed length scales. Solutions have been obtained for both the instantaneous and time-averaged velocity components in the sublayer. The expression for the time-averaged streamwise velocity profile contains two parameters, the friction velocity and a parameter related to the bursting frequency. Both quantities are real and measurable features of the flow. The expression for the time-mean profile has been very accurately fit to a considerable variety of experimentally measured time-mean profiles by suitable adjustment of the aforementioned parameters. In particular, the model is capable of describing flows which are approaching separation. Work is continuing on the development of the model and also on a predictive method for turbulent separation.
(*h*) **Numerical Solution of Turbulent Boundary Layers Approaching Separation,** D. E. Abbott, J. D. A. Walker, R. E. York, *Proc. 4th Intl. Conf. Num. Meth. Fluid Dynamics*, Boulder, Colo., 1974.

142-08947-290-54

AN EXPERIMENTAL INVESTIGATION OF DIFFUSER GENERATED FLOW UNSTEADINESS

(*b*) Mechanics Division, National Science Foundation.
(*c*) Dr. Charles R. Smith, Assistant Professor.
(*d*) Experimental; basic research.
(*e*) An investigation of the types of pressure and flow unsteadiness generated by the presence of a diffuser operating in the transitory stall flow regime (near maximum recovery). Measurement of pressure and velocity fluctuations are being used to establish the relationship of diffuser geometry and inlet conditions on unsteady flow behavior. Auto and cross-correlation techniques are being used to establish propagation and periodic characteristics of unsteady properties. Experiments are carried out on a specially constructed suction flow facility with operating capabilities of 15 lbm/sec and inlet Mach numbers to choking.
(*g*) Flow unsteadiness appears very sensitive to inlet throat geometry and inlet conditions. Shorter length ratio dif-

fusers generate higher frequency disturbances, whereas longer length ratio diffusers produce large amplitude disturbances.

142-08948-700-15

DEVELOPMENT OF LASER-DOPPLER VELOCIMETER (LDV)

(*b*) U. S. Army Missile Command.
(*c*) W. H. Stevenson, H. D. Thompson, School of Mechanical Engineering.
(*d*) Experimental and theoretical, basic through development, Doctoral dissertation.
(*e*) Design, build and test an LDV system for flow velocity measurements for both low speed and high speed flows.
(*f*) Completed.
(*g*) A unique data processing system was designed, built and tested for flow velocities up to 2000 ft/sec.

THE RAND CORPORATION, Department of Physical Sciences, 1700 Main Street, Santa Monica, Calif. 90406. Dr. R. M. Salter, Department Head. (Publications may be purchased.)

143-06790-480-18

CLOUD DYNAMICS AND CLOUD PHYSICS

(*b*) Navy Environmental Prediction Research Facility.
(*c*) F. W. Murray.
(*d*) Theoretical; basic and applied.
(*e*) With the ultimate objective of advancing cloud physics studies and providing inputs for an atmospheric model for numerical weather prediction, this is an attempt to develop a computer model of a cumulus cloud that follows the growth from the start of convection. Other basic studies include the microphysical effects of cloud-droplet coalescence, ice crystal nucleation, and other processes.
(*g*) Parameterized microphysics of liquid and ice processes has been incorporated into a hydrodynamical model. The relative importance to cloud growth and decay of various processes has been clarified.
(*h*) **Parameterization of Ice Growth for Numerical Calculations of Cloud Dynamics,** L. R. Koenig, *R-846-NOAA*, 25 pages, July 1971.
Numerical Experiments on the Relation Between Microphysics and Dynamics in Cumulus Convection, F. W. Murray, L. R. Koenig, *R-852-ARPA*, 43 pages, Aug. 1971.
Calculation of the Terminal Velocity of Water Drops, H. B. Wobus, F. W. Murray, L. R. Koenig, *P-4564*, 12 pages, Jan. 1971.

143-06793-270-40

FLUID MECHANICS OF THE HUMAN MICROCIRCULATION

(*b*) National Institutes of Health.
(*c*) Dr. Carl Gazley, Jr.
(*d*) Theoretical; applied research.
(*e*) Study of the fluid mechanics of the human microcirculation. Development of analytical and numerical models of the flow and diffusional transport in the small vessels of a microcirculatory network. Current emphasis is on the effects of non-Newtonian and pulsatile-flow aspects.
(*g*) Analytic models have been developed of plasma motion and mass transfer between red cells in a capillary, non-Newtonian flow in an arteriole, and pulsatile non-Newtonian flow in a microcirculation network.
(*h*) **Small-Scale Phenomena in the Flow of Dispersion,** C. Gazley, Jr., *P-4796*, 25 pages, Mar. 1972.
The Fluid Mechanics of Pulsatile Flow in the Microcirculation, J. F. Gross, J. Aroesty, *P-4785*, 12 pages, Mar. 1972.

143-06795-860-65

DEVELOPMENT OF WATER QUALITY SIMULATION MODEL

(*b*) City of New York.
(*c*) J. J. Leendertse.
(*d*) Applied.
(*e*) Develop a computational model for the flow in estuaries and coastal seas, combined with a model for the advective and diffusive transport of pollutants, which also permits simulation of reactions of pollution substances.
(*g*) The model for the flow and the advective and diffusive transport of pollutants in well-mixed waters has been developed and is being evaluated for Jamaica Bay, New York. The two-dimensional model includes flow over tidal flats which may become exposed during ebb. Results are presented in graphs and charts with isocontours of concentrations. The model is being used in support of the extent and control of pollutants in the Bay.
(*h*) **A Water-Quality Simulation Model for Well Mixed Estuaries and Coastal Seas. Volume VI, Simulation, Observation, and State Estimation,** J. J. Leendertse, S.-K. Liu, *R-1586-NYC*, Dec. 1974.
Stochastic Analysis and Control of Urban-Estuarine Water-Quality Systems. Volume I, Estimation and Prediction, S.-K. Liu, *R-1622-NYC* (in process of publication).

143-08952-400-33

DEVELOPMENT OF A THREE-DIMENSIONAL MODEL FOR ESTUARIES AND COASTAL SEAS

(*b*) Department of Interior, Office of Water Resources and Technology.
(*c*) J. J. Leendertse.
(*d*) Applied research.
(*e*) Develop a finite difference model which can be used to compute the flow in estuaries with nonisotropic density. The model is intended to be used in engineering and scientific investigations of estuaries with complicated bathymetry and flow patterns.
(*h*) **A Three-Dimensional Model for Estuaries and Coastal Seas. Volume I, Principles of Computation,** J. J. Leendertse, R. C. Alexander, S.-K. Liu, *R-1417-OWRR*, Dec. 1973.

RENSSELAER POLYTECHNIC INSTITUTE, Department of Mathematical Sciences, Troy, N. Y. 12181. Dr. Richard C. DiPrima, Department Chairman.

144-06772-000-20

STABILITY OF VISCOUS FLOW OVER CURVED SURFACES

(*b*) Office of Naval Research.
(*c*) Professors R. C. DiPrima, D. A. Drew.
(*d*) Theoretical; basic research.
(*e*) Stability and two-phase effects are studied in an effort to achieve basic understanding of fluid flows which have importance in applications.
(*g*) Several investigations have been made of fundamental nonlinear effects in hydrodynamic stability. Azimuthal effects have been considered in a major linear stability theory calculation for eccentric cylinders. The work has been extended to include nonlinear effects, and the secondary flow has been calculated. The work has importance for stability theory generally for classes of flows which vary in the direction of the flow, and for the lubrication of lightly loaded journal bearings in particular. Constitutive equations and basic stability problems in two-phase flows have been studied. Also see 144-06773-000-14.
(*h*) **Flow Between Eccentric Rotating Cylinders,** R. C. DiPrima, J. T. Stuart, *J. Lubrication Tech.* **94,** pp. 266-274, 1972.
Non-Local Effects in the Stability of Flow Between Eccentric Rotating Cylinders, R. C. DiPrima, J. T. Stuart, *J. Fluid Mech.* **54,** pp. 393-416, 1972.

Some Effects of Suspended Particles on the Onset of Benard Convection, J. W. Scanlon, L. A. Segel, *Phys. Fluids* **16**, pp. 1573-1578, 1973.
Effects of a Coriolis Force on the Stability of Plane Poiseuille Flow, R. Wollkind, R. C. DiPrima, *Phys. Fluids* **16**, pp. 2045-2051, 1973.
Development and Effects of Super-Critical Taylor-Vortex Flow in a Lightly Loaded Journal Bearing, R. C. DiPrima, J. T. Stuart, *J. Lubrication Technology* **96**, pp. 28-35, 1974.
A Numerical Study of the Formation and Propagation of Traveling Bands of Chemotactic Bacteria, T. L. Scribner, L. A. Segel, E. H. Rogers, *J. Theor. Biol.* **46**, pp. 189-219, 1974.

144-06773-000-14

NONLINEAR PROBLEMS IN FLUID MECHANICS

(*b*) U.S. Army Research Office – Durham.
(*c*) Professors R. C. DiPrima, L. A. Segel.
(*d*) Theoretical; basic research.
(*e*) Nonlinear stability theory and formal averaging techniques are applied to the study of flow processes. Singular perturbation theory is applied to problems in gas bearing lubrication theory. Chemotactic problems in bio-fluid mechanics are also being considered.
(*g*) Results for the existence and uniqueness of the solution to the gas slider bearing problem have been obtained and an asymptotic representation of the solution is given for large bearing numbers. An analysis of the wavy vortex flow between concentric rotating cylinders suggests that the flow with azimuthal wave number 4 may dominate other growing modes (according to linear theory) at speeds slightly greater than critical. A number of situations where populations of chemotactic bacteria respond to chemical gradients have been analyzed. Also see 144-06772-000-20.
(*h*) **Instability of a Layer of Chemotactic Cells, Attractant and Degrading Enzyme,** L. A. Segel, B. Stoeckly, *J. Theor. Biol.* **37**, pp. 561-585, 1972.
Non-Local Effects in the Stability of Flow Between Eccentric Rotating Cylinders, R. C. DiPrima, J. T. Stuart, *J. Fluid Mech.* **54**, pp. 393-416, 1972.
Theoretical Analysis of Chemotactic Movement in Bacteria, L. A. Segel, J. L. Jackson, *J. Mechanochem. Cell Motility* **2**, pp. 25-34, 1973.
Effect of a Coriolis Force on the Stability of Plane Poiseuille Flow, R. Wollkind, R. C. DiPrima, *Phys. Fluids* **16**, pp. 2045-2051, 1973.
On a Nonlinear Singular Perturbation Boundary Value Problem In Gas Lubrication Theory, W. J. Steinmetz, *SIAM J. Appl. Math.* **26**, pp. 816-827, 1974.
On the Torque of Wavy Vortices, P. M. Eagles, *J. Fluid Mech.* **62**, pp. 1-9, 1974.
Evolution of Unstable Shear Layers in a Rotating Fluid, W. L. Siegmann, *J. Fluid Mech.* **64**, pp. 289-305, 1974.
A Numerical Study of the Formation and Propagation of Traveling Bands of Chemotactic Bacteria, T. L. Scribner, L. A. Segel, E. H. Rogers, *J. Theor. Biol.* **46**, pp. 189-219, 1974.

RENSSELAER POLYTECHNIC INSTITUTE, Department of Mechanical Engineering, Aeronautical Engineering and Mechanics, Troy, N. Y. 12181. Robert Duffy, Associate Professor of Aeronautical Engineering.

145-09653-270-00

BIOMECHANICS OF KOROTKOFF SOUND PRODUCTION, VALSALVA MANEUVER INDUCED VENA CAVA FLUTTER, URETER VALVE FLUTTER, AND OTHER RELATED PHENOMENA

(*c*) Henry A. Scarton.
(*e*) A self-excited large deformation elastic snap-through streaming viscous fluid relaxation oscillation of the brachial artery, vena cava, and ureter have been experimentally shown to be produced as a result of a condition where the external pressure exceeds the internal static tube pressure. In the brachial artery, these oscillations are responsible for the production of Korotkoff sounds which are used in the auscultatory method of blood pressure determination; in the vena cava, these oscillations are an unwanted and dangerous source of viscous pressure drop; in the ureter, these oscillations serve the useful purpose of inhibiting backflow into the kidney from the bladder during bladder expulsion. Similar phenomena also occur in the cochlea of the inner ear. In all of these applications it is desirable to know the precise parametric nature of the oscillation. To date no analysis exists which can predict this oscillation other than in a simple minded fashion. To this end a comprehensive analytical and experimental determination is being carried out.

145-09654-270-00

BIOMECHANICS OF AORTIC ATHEROMA

(*c*) Henry A. Scarton.
(*e*) The spatial distribution of early atheroma has been shown experimentally to be coincident with those regions of the curved aortic wall where the velocity gradient, and hence wall shear and mass transport, is low; for the proximal ascending aorta, this region is the inside wall closest to the center of aortic curvature. Independent experiments have shown that the entry aortic fluid core velocity distal to the left ventricle behaves as if it were inviscid so that it varies as the reciprocal of the tube principal radius of curvature and hence is paradoxically lower near the outside than near the inside curved wall. The presence of a centrifugally induced secondary flow is then required in order to thin the outer wall viscous boundary layer and consequently steepen the radial velocity gradient to produce an increase in outer wall mass transfer. Both experimental flow visualization techniques and the analytical determination of this three-dimensional boundary layer in the entry region of the proximal ascending aorta are being carried out.

145-09655-030-00

FLOW-INDUCED VIBRATIONS IN NUCLEAR FUEL ROD BUNDLES

(*c*) Henry A. Scarton.
(*e*) Flow induced vibrations and collapse phenomena occur in nuclear fuel rod bundles and reactor heat exchanger plating. These oscillations and buckling phenomena are an unwanted and dangerous effect which must be properly understood in order that proper preventative design techniques can be employed. Analytical treatments of the problem are being undertaken.

145-09656-600-00

SIGNAL SIMULATION OF STEADY PERIODIC WAVES, ACOUSTIC TRANSIENTS, AND ACOUSTIC STREAMING IN FLUIDIC DELAY LINES

(*c*) Henry A. Scarton.
(*e*) In recent years much attention has been focused on the propagation of small amplitude steady-periodic pressure waves through fluids confined in rigid tubes. Although a problem long of intrinsic interest to acousticians, most of the recent research has been spurred on by technological developments in fluid transmission lines and acoustic delay lines, and the desire for better mathematical models of biological flows, particularly arterial blood flow. The effects of viscosity cannot be ignored in these applications, in contrast to the customary acoustic approach. But in the few instances where viscosity has been considered, the analyses have been confined to simplified dynamic models (e.g., quasi-steady and/or plane pressure waves have been assumed), or else incomplete. Analytic studies are being employed to study steady-periodic signal simulation, acoustics transients, and acoustic streaming in viscous compressible liquid-filled rigid delay lines.

145-09657-710-00

FLUID VELOCITY MEASUREMENT BY PARTICLE TRACKING

(c) E. F. C. Somerscales.
(e) A review and compilation of techniques of fluid velocity measurement by measuring the motion of flow tracing particles suspended in the fluid. Both the characteristics of the flow tracing particles and the observation systems are considered. The particle characteristics include: dynamics, production, introduction into flow, and optical. The observation system characteristics include'description and classification of various optical systems, dynamic characteristics and sensitivity.

145-09658-000-00

FREE CONVECTION STABILITY

(c) E. F. C. Somerscales.
(e) Experimental study of the flow patterns at the initiation of convection in a layer of fluid heated from below. Data is analyzed on a specially constructed optical computer.

145-09659-870-70

THE RISE OF A MOIST PLUME IN THE ATMOSPHERE

(b) Empire State Electric Energy Research Corporation.
(c) Henry J. Sneck.
(e) The rise of a moist, warm plume from a large-size source (such as a power plant cooling tower) is being modeled in an environmental chamber and mathematically to determine how the conditions at the source and in the atmosphere affect the visible portion of the plume. Results will provide cooling tower operators with the means to predict beforehand when fogging and icing conditions are likely to occur during atmospheric temperature inversions.

145-09660-620-00

EFFECTS OF INERTIA AND COMPRESSIBILITY IN LUBRICATION

(c) H. J. Hagerup.
(e) This study involves analytical investigations of inlet effects in inherently restricted hydrostatic and Rayleigh-stepped bearings, otherwise operating in the laminar flow regime. The problems are considered essentially in terms of the full Navier-Stokes equations, using the method of weighted residuals.

145-09661-520-00

PERIPHERAL-JET PERFORMANCE STUDIES

(c) H. J. Hagerup.
(e) Analytical investigations have been made which have so far been primarily concerned with the fluid mechanics of both laminar and turbulent exit flow separation, and its effect on peripheral jet ground effect machine performance.

145-09662-010-00

A STUDY OF BOUNDARY LAYER CHARACTERISTICS ON AXISYMMETRIC BODY WITHIN A TUBE

(c) W. B. Brower.
(e) With the increasing congestion of airport facilities, the public concern over aircraft "noise pollution," and the poor proximity of airports to urban centers, high-speed ground transportation shows growing promise as an alternative to the conventional airliner. For a number of reasons, one of the most viable plans calls for a long, slender vehicle, shaped somewhat like an aircraft fuselage, which "flies" through a tube. For this reason, the boundary layer and drag characteristics of such a configuration become important, in order to minimize the vehicle's energy consumption.
This project involves an experimental approach to the problem. Suitably modified "tubeflight" models are mounted in the Tube Transportation Facility, and boundary layer surveys are performed in the tube ahead of the model, in the transfer passage between the vehicle and the tube wall, and in the wake behind the vehicle. Different methods, including possibly the use of total, static, Stanton, or Preston tubes will be used and comparisons made. In addition, visual techniques will be employed to determine the skin friction drag on both the body and the tube walls, and again the different experimental methods will be compared. And finally, the effect of vehicle tail shape on the drag will be investigated.
Although the boundary conditions of the proposed experimental study are not the same as for the real case (the model is stationary with respect to the tube, rather than moving relative of it) it is anticipated that this study can serve as a starting point for analytical or other experimental studies which take into account the proper boundary conditions.

RUTGERS UNIVERSITY, The State University of New Jersey, College of Engineering, Department of Mechanical, Industrial and Aerospace Engineering, New Brunswick, N. J. 08903. Dr. R. H. Page, Department Chairman.

146-07616-090-00

SEPARATED FLOWS

(c) Professor R. H. Page.
(d) Experimental and theoretical basic research.
(e) Basic research in separated flows is being carried out to determine a much more fundamental understanding of the thermodynamic and dynamic mechanisms.
(g) Special experimental research facilities have been developed and theoretical models of various separated or separating flows have been formulated.
(h) **Visualization of Recirculation Regions,** R. H. Page, *Workshop on Flow Visualization and Flow Measurement Techniques, NOLTR 72-94*, NOL, Silver Spring, Md., May 1972.
Wollaston Prism Schlieren Interferometer, R. H. Page, *Workshop on Flow Visualization and Flow Measurement Techniques, NOLTR 72-94*, NOL, Silver Spring, Md., May 1972.
A Review of Component Analysis of Base Pressure for Supersonic Turbulent Flow, R. H. Page, *10th Intl. Symp. Space Technology and Science*, Tokyo, Sept. 1973.

146-07618-720-80

EMIL BUEHLER WIND TUNNEL

(b) Emil Buehler Foundation.
(c) Professor R. H. Page.
(d) Design; development.
(e) Design, operation, and development, of a supersonic variable Mach number wind tunnel and auxiliary apparatus for teaching and research programs. A variable Mach number wind tunnel (up to Mach 4.0) has been used extensively since it was first operated on April 21, 1964. It is used for teaching and research programs.
(g) Improvements in the tunnel's operation have been continuously made.
(h) **Apparent Relaminarization of a Supersonic Boundary Layer,** J. L. Owen, R. H. Page, *Canad. Congr. Appl. Mech.*, Montreal, Canada, pp. 587-588, May 1973.
Turbulent Supersonic Boundary Layer Flow in the Neighborhood of a 90° Corner, R. D. Small, R. H. Page, *Astronautica Acta* **18**, 2, pp. 99-107, Apr. 1973.

146-07619-600-00

FLUIDICS RESEARCH

(c) Professor R. H. Page.
(d) Theoretical and experimental investigations.

(*e*) Theoretical analyses of separating and reattaching flows are being carried out and verified with specially designed experiments.

(*g*) Basic fluid mechanics of supersonic separation and reattachment for fluidic devices has been formulated.

(*h*) **An Analog Investigation of the Gas Jet Resonance Tube,** M. A. Skok, R. H. Page, *5th Cranfield Fluidics Conf.*, Univ. of Uppsala, Sweden, June 14, 1972.

Resonance in a Piston-Driven Cavity, P. P. Pandolfini, R. H. Page, *Computer Methods in Applied Mechanics and Engrg.* **3**, pp. 29-36, 1974.

Finite Difference Techniques for Variable Area Shock Tube Flows, P. P. Pandolfini, R. H. Page, *Proc. 10th Southeastern Sem. on Thermal Sciences*, Dept. Mech. Engrg., Tulane Univ., New Orleans, La., pp. 378-399, Apr. 1974.

146-07621-030-26

THE TURBULENT WAKE OF AN AXISYMMETRIC BODY AT SUBSONIC SPEEDS

(*b*) Air Force Office of Scientific Research and Rutgers Research Council.

(*c*) Associate Professor C. E. G. Przirembel.

(*d*) Experimental, theoretical; basic research.

(*e*) The near-wake of an axisymmetric body, which is immersed in a uniform subsonic flow field, has been investigated experimentally and theoretically. The basic model was a circular cylinder aligned with the free stream direction. The geometry of the base was varied depending on the purpose of the particular investigation. Fundamental understanding of this near-wake flow field is necessary for the prediction of base drag, base heat transfer, and the configuration of the associated far wake. For example, this type of flow field characterizes fluid motion around such diverse objects as missiles, aircraft, buses and flowmeter elements.

(*f*) Completed.

(*g*) The support system for these models was designed to eliminate any support interference effects on the free stream and the approaching boundary layer. Detailed pressure and velocity measurements in all regions of the near-wake and in the approaching flow have been obtained for numerous base geometries. Results are discussed in the various publications listed below.

(*h*) **The Turbulent Near-Wake of An Axisymmetric Body at Subsonic Speeds,** D. P. McErlean, C. E. G. Przirembel, *AIAA Paper No. 70-797*, AIAA 3rd Fluid and Plasma Dynamics Conf., June 1970.

Subsonic Turbulent Wakes of Axisymmetric Bodies, C. E. G. Przirembel, *Proc. THEMIS Symp. Vehicular Dynamics*, Rock Island Arsenal, Ill., Nov. 1971.

Incompressible Turbulent Boundary Layer Separation From a Curved Axisymmetric Body, C. H. Yi, C. E. G. Przirembel, *Developments in Mechanics* **7**, *Proc. 13th Midwestern Mech. Conf.*, Univ. of Pittsburgh, Aug. 1973.

Effect of Sting Supports on Subsonic Base Pressures, C. E. G. Przirembel, *Proc. 10th Intl. Symp. Space Technology and Science*, Tokyo, Japan, Sept. 1973.

146-08259-020-54

TURBULENCE AND TURBULENT DIFFUSION IN STRATIFIED FLOW

(*b*) National Science Foundation.

(*c*) Professor Richard L. Peskin.

(*d*) Theoretical and experimental research.

(*e*) To study the structure of turbulence in stratified flow with particular application of the atmospheric boundary layer. The Langevin theory for turbulent diffusion is being modified to be applicable to problems in stratified turbulent flow. This theory is of interest in estimation of turbulent diffusion. Three-dimensional numerical simulation of the channel flow is being revised and boundary conditions appropriately changed to effect simulation of the atmospheric boundary layer. Data tapes from the Bomex experiment are being analyzed to obtain more information on microstructure and dissipation rates in stratified turbulence and a wind tunnel experiment is being performed to investigate the approach to isotropy and the effect of stratification on this approach.

(*h*) **The Langevin Model for Turbulent Diffusion,** Krasnoff and Peskin, *Geophysical Fluid Dynamics*, 1971.

146-08260-130-54

INVESTIGATION OF GAS-PARTICLE SHEAR FLOWS

(*b*) National Science Foundation.

(*c*) Professor R. L. Peskin.

(*d*) Theoretical and experimental applied research.

(*e*) To investigate three-dimensional shear flows. Theoretical study using a new stochastic estimation model was undertaken to study both the Eulerian-Lagrangian problem and the application of Eulerian-Lagrangian relation to diffusion. The same stochastic estimation model was also used to study finite particle motion in turbulent flow. Analytical results include prediction of effective Schmidt number ratios, that is, the ratio of particle diffusivity to eddy diffusivity of turbulence. A numerical simulation of channel flow was developed involving over 10,000 grid points. This three-dimensional simulation was used to study the Eulerian structure of channel flow, the Lagrangian structure of such flows, and the motion of particles in turbulent shear flow. Among the various results obtained were numerically predicted particle Schmidt numbers. It was shown that the Schmidt number depends in large measure on the nature of shear flow and that the presence of shear has a larger effect on fluid points than on solid particles. Of significance was the test of the Corrsin hypothesis between Lagrangian correlation and Eulerian space-time correlation. Experimentally, a laser-Doppler anemometer has been developed to study the finite particles in a turbulent flow. This highly accurate system enables investigation of particle velocity statistics in the shear flow and is capable of extension to obtain both gas turbulence and particle fluctuation information simultaneously.

(*h*) **Stochastic Estimation Applications to Turbulent Diffusion,** R. L. Peskin, *Proc. Intl. Symp. Stochastic Hydraulics*, Univ. of Pittsburgh, 1971.

Numerical Simulation of Turbulence and Diffusion in Three-Dimensional Flow, Kau and Peskin, Mar. 1972.

146-08261-060-54

STUDIES IN THERMOHALINE CONVECTION

(*b*) National Science Foundation.

(*c*) Professor C. F. Chen.

(*d*) Experimental and theoretical; basic research.

(*e*) Investigate possible mechanisms for the genesis and maintenance of microstructures found in many parts of the world's ocean. Specifically, we study the onset of horizontal cellular convection in a stratified fluid due to an imposed horizontal temperature gradient. This investigation was extended to examine Couette instability of density stratified fluid.

(*f*) Completed.

(*g*) For the time-dependent Couette flow, a linear stability analysis based on the initial-value problem approach has been developed and it proved to be quite successful. A computer simulation based on axisymmetric Navier-Stokes equation has been completed which compared favorably with the experiments. The effect of constant acceleration rate of the inner cylinder has also been examined. Some results of oscillating flow have been obtained. In a steady Couette flow, density stratification in the vertical direction enhances the stability of flow. A linearized stability analysis has yielded results which are in good agreement with the experimental data.

(*h*) **Physical and Numerical Experiments on Time-Dependent Rotational Couette Flow,** D. C. S. Liu, *Ph.D. Thesis*, Dept. of Mech. and Aerospace Engrg., Rutgers Univ., June 1971.

Couette Instability in Stratified Fluids, E. M. Withjack, *Ph.D. Thesis*, Dept. of Mech. and Aerospace Engrg., Rutgers Univ., Feb. 1974.

Stability of Time-Dependent Rotational Couette Flow – Part 2, Stability Analysis, C. F. Chen, R. P. Kirchner, *J. Fluid Mech.* **48**, p. 365, 1971.

Channel Flow of a Density-Stratified Fluid About Immersed Bodies, J. V. Droughton, C. F. Chen, *J. Basic Engrg.* **97**, Series D, pp. 122-130, 1972.

Stability of Circular Couette Flow with Constant Finite Acceleration, C. F. Chen, D. C. S. Liu, M. W. Skok, *J. Appl. Mech* **40**, pp. 347-354, 1973.

Numerical Experiments on Time-Dependent Rotational Couette Flow, D. C. S. Liu, C. F. Chen, *J. Fluid Mech.* **59**, pp. 77-98, 1973.

Studies of Time-Dependent Rotational Couette Flow, C. F. Chen, *Proc. 10th Anniv. Mtg. Soc. Eng. Sci.*, 1974.

An Experimental Study of Couette Instability of Stratified Fluids, E. M. Withjack, C. F. Chen, *J. Fluid Mech.* **66**, pp. 707-720, 1974.

Stability Analysis of Rotational Couette Flow of Stratified Fluids, E. M. Withjack, C. F. Chen, *J. Fluid Mech.* (to appear).

146-08949-090-54

STUDIES IN DOUBLE-DIFFUSION CONVECTION

(*b*) National Science Foundation.
(*c*) Professor C. F. Chen.
(*d*) Experimental and theoretical; basic research.
(*e*) This research involves study of the formation and structure of horizontal layers in a fluid mixture subjected to double-diffusion. Two situations will be considered, one in which the diffusing quantities are heat and salt, and the other in which the diffusing substances are sugar and salt. In the first case experiments will be conducted on a stratified salt solution subjected to a lateral temperature gradient, the fluid being contained between plates at different temperatures with the hotter plate sloping away from the fluid. The stability of the fluid will be analyzed by linear analysis, and the fully developed convection cells will be analyzed by nonlinear numerical calculations. In the second case concentration measurements will be obtained for combinations of stabilizing and destabilizing gradients of sugar and salt in order to determine stability and the nature of the diffusive, fingering and layering phenomena in the fluid. Experiments with a sloping plate boundary will also be performed for the sugar-salt solutions.
(*g*) For a heated plate at 45° from the vertical, the critical Rayleigh number above which cellular convection appears has been determined. It is somewhat larger than the value determined for the vertical wall. For a double-diffusive situation with continuous opposing vertical gradients of salt and sugar, layers can be generated by a number of two-dimensional disturbances.
(*h*) **Cellular Convection in a Salinity Gradient Along a Heated Inclined Wall,** C. F. Chen, M. W. Skok, *Intl. J. Heat Mass Transfer* **17**, pp. 51-60, 1974.

Onset of Cellular Convection in a Salinity Gradient Due to a Lateral Temperature Gradient, C. F. Chen, *J. Fluid Mech.* **13**, pp. 563-576, 1974.

Two-Dimensional Effects in Double-Diffusive Convection, J. S. Turner, C. F. Chen, *J. Fluid Mech.* **63**, pp. 577-593, 1974.

Onset of Double-Diffusive Instability in a Salinity Gradient Due to Lateral Heating, *Proc. 5th Intl. Heat Transfer Conf.*, pp. 178-182, 1974.

146-08950-290-15

ANALYSIS OF RESONANCE TUBES

(*b*) Picatinny Arsenal, Department of the Army.
(*c*) Associate Professor C. E. G. Przirembel.
(*d*) Experimental, theoretical; basic research.
(*e*) The flow field associated with a two-dimensional resonance tube is being investigated. The test parameters, which are being varied in the experimental program, are the nozzle jet stagnation pressure, the ratio of the separation distance between the nozzle and the resonance tube to the nozzle exit height, and the ratio of the resonance tube length to the nozzle exit height. Pressure and temperature measurements are being obtained at the resonance tube endwall. Color Schlieren, Schlieren and shadowgraph flow visualization techniques, in conjunction with high speed motion picture techniques, are used in observing and analyzing the expansion and compression regions.
(*g*) For a resonance tube with a blunt leading edge, it has been determined that the maximum resonant condition exists when the leading edge is located in the third compression cell of the jet. The blunt geometric configuration of the leading edge seems to prevent formation of a strong normal shock in the resonance tube. The shadowgraph high speed motion pictures show that significant pressure disturbances propagate from the resonance tube to the nozzle exit.
(*h*) **A Flow Visualization Study of a Resonance Tube,** C. E. G. Przirembel, *RU-TR 144-MIAE-F*, Dept. of Mechanical, Industrial, and Aerospace Engrg., Rutgers Univ., July 1974.

146-08951-050-00

HIGH SPEED WATER JET

(*c*) Professor R. H. Page.
(*d*) Theoretical and experimental investigations.
(*e*) Stability of high-velocity liquid jets are investigated. Experimental program utilizes a small diameter pulsed liquid jet with several nozzle designs at a maximum velocity of 1,000 meters per second.
(*g*) A model based on small perturbation theory with linearized equations of motion was chosen for analysis. Short time duration laser photographs of water and glycerine-water jets exhibited a ring-type instability having a small wave length. A non-interfering probe consisting of a miniature pressure cell utilizing strain gages was developed in order to measure pressures in the water jet.
(*h*) **Stability of a High-Velocity Water Jet in a Cutting Configuration,** J. C. Dunn, *Ph.D. Thesis*, Rutgers Univ., 1973.

SANDIA LABORATORIES, Aerosciences Research Department, Organization 5640, Albuquerque, N. Mex. 87115. Dr. K. J. Touryan, Department Manager.

147-08265-000-52

STABILITY OF LIQUID FILMS

(*b*) Energy Research and Development Administration.
(*c*) William S. Saric.
(*d*) Experimental and theoretical.
(*e*) Experimentally and theoretically identify the regions of stable and unstable behavior of a liquid layer interacting with a supersonic airstream. This models the liquid-gas configuration that is present in ablating layers or transpiration cooling systems.
(*g*) The stability of liquid films adjacent to compressible streams is investigated analytically as well as experimentally. Linear theories predict that films adjacent to supersonic streams are much more unstable than those adjacent to subsonic streams in qualitative disagreement with our experimental observations. Although stability parameters were matched in the subsonic and supersonic experiments, we found that films adjacent to supersonic streams are stable while those adjacent to subsonic streams are unstable, as evidenced by the entrainment of the liquid by the gas. These experimental observations can be explained by nonlinear theories which predict that linear unstable disturbances achieve steady state amplitudes in the supersonic case and continue to be unstable in the subsonic case.
(*h*) **Nonlinear Waves in a Kelvin-Helmholtz Flow,** A. H. Nayfeh, W. S. Saric, *J. Fluid Mech.* **55**, pp. 311-327, 1972.

Nonlinear Stability of a Liquid Film Adjacent to a Supersonic Stream, A. H. Nayfeh, W. S. Saric, *J. Fluid Mech.* **58**, pp. 39-51.

Stability of Liquid Films Adjacent to Compressible Streams, G. L. Bordner, A. H. Nayfeh, W. S. Saric, *Intl. J. Engrg. Science.*

147-08266-020-52

STATISTICAL TURBULENCE

(*b*) Energy Research and Development Administration.
(*c*) Dr. R. L. Fox.
(*d*) Theoretical.
(*e*) Develop tractable statistical methods for calculating turbulent flow without reliance on empirical parameters.
(*g*) The turbulence field is modeled by a fluid of non-conservative interacting pseudo-particles. The statistical relations for the pseudo-particles are developed in such a manner as to reproduce the Navier-Stokes equations for an incompressible turbulent fluid when appropriate averages are applied. Comparison of predicted results for homogeneous isotropic media is in reasonable agreement with experimental data.
(*h*) **Multipoint Distribution Calculation of the Isotropic Turbulent Energy Spectrum Using Self-Consistent Initial Conditions,** R. L. Fox, *Phys. Fluids* **17,** p. 846, 1974.
Multipoint Distribution Calculation of the Isotropic Turbulent Energy Spectrum, R. L. Fox, *Phys. Fluids* **16,** p. 977, 1973.
Investigation of the Relation Between the Turbulent Energy Spectrum and the Energy Transfer Function for Isotropic Fluids, R. L. Fox, *Research Rept. SC-RR-72-0826;* request from author.
Distribution Functions in the Statistical Theory of Compressible Turbulent Fluids, *Research Rept. SAND74-0119;* request from author.

147-08973-010-52

COMPUTATIONAL FLUID DYNAMICS

(*b*) Energy Research and Development Administration.
(*c*) Dr. Frederick G. Blottner, Dr. Roger R. Eaton.
(*d*) Numerical, applied research.
(*e*) Finite-difference techniques are being developed for solving boundary layer, inviscid and Navier-Stokes equations as occur in reentry vehicle flow fields and other systems of interest.
(*g*) A computer program has been developed for solving the incompressible three-dimensional boundary-layer equations on blunt bodies at incidence. A numerical procedure is used to obtain an orthogonal coordinate system on the surface of the body. A variable grid scheme has been developed for use with a Crank-Nicolson-type finite-difference procedure. This method has been applied to turbulent boundary layers, and it has been shown that second-order accurate results can be obtained with a reasonable number of grid points across the layer. In addition, a review of various finite-difference techniques for solving the boundary-layer equations has been made.
A marching method has been developed for obtaining solutions to the viscous flow between the body and shock in the symmetry plane of sharp or blunt bodies at angle of attack in hypersonic flight. The flexibility of the technique in the calculation of laminar, transitional, and turbulent flows extends the application of the method over a wide range of Reynolds numbers. In this approach, shock-layer solutions are obtained by employing a single, parabolic set of equations developed from the general steady-state, Navier-Stokes equation using effective transport parameters. Comparisons of numerical results with laminar and turbulent experimental data corroborate the validity of this approach.
(*h*) **Finite-Difference Solution of the Incompressible Three-Dimensional Boundary Layer Equations for a Blunt Body,** F. G. Blottner, M. A. Ellis, *J. Computers and Fluids* **1,** pp. 133-158, 1973.
Variable Grid Scheme Applied to Turbulent Boundary Layers, F. G. Blottner, in *Computer Methods in Applied Mechanics and Engineering* **4,** pp. 179-194, 1974.
Computational Techniques for Boundary Layers, F. G. Blottner, in *AGARD Lecture Series 73, Computational Methods for Inviscid and Viscous Two- and Three-Dimensional Flow Fields,* 1975.
Viscous Shock Layer Flow in the Windward Planes of Cones at Angle of Attack, R. R. Eaton, P. C. Kaestner, *AIAA J.* **11,** 9, p. 1336, Sept. 1973.
Laminar and Turbulent Viscous Shock Layer Flow in the Symmetry Planes of Bodies at Angle of Attack, R. R. Eaton, D. E. Larson, *AIAA Paper No. 74-599.*
Symmetry Plane Laminar and Turbulent Viscous Flow on Bodies at Incidence, R. R. Eaton, D. E. Larson, to be published in *AIAA J.,* request from author.

SCIENCE APPLICATIONS, INCORPORATED, P. O. Box 2351, 1200 Prospect Street, La Jolla, Calif. 92037. Dr. J. A. Young, Director of Theoretical Division.

148-08975-520-20

FLOATING BODY CALCULATIONS

(*b*) Office of Naval Research.
(*c*) Dr. Robert K.-C. Chan.
(*d*) Theoretical study.
(*e*) Study feasibility, advantages, and limitations of using direct numerical simulation techniques in the study of floating-body motions. Three simulation techniques, the Generalized Arbitrary Lagrangian-Eulerian (GALE) method, the Transient Potential Flow (TPF) method, and the extended Galerkin method have been considered.
(*f*) Two-dimensional studies have been completed. Three-dimensional calculations were initiated in July 1974.
(*g*) Both GALE and TPF methods have been used to calculate the heaving of a semi-submerged circular cylinder in the free surface. The computed hydrodynamic forces, the added mass, and the damping coefficient are in good agreement with linear analytic theory and measurements.
(*h*) **Two-Dimensional Calculations of the Motion of Floating Bodies,** R. K.-C. Chan, C. W. Hirt, *Proc. 10th Symp. Naval Hydrodyn.,* Boston, 1974.

148-08976-040-21

FLOW ABOUT A PLANING SURFACE

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. Robert K.-C. Chan or Mr. Gary T. Phillips.
(*d*) Theoretical study.
(*e*) Prove the feasibility and validity of numerical models to provide a better theoretical understanding of hydroplaning and hydrofoil processes.
(*g*) A computer code, SKIMMER, has been developed to solve the Navier-Stokes equations for time-dependent, two-dimensional imcompressible flow with a free surface. Preliminary results indicate good agreement with linear steady-state solutions for the case of a prescribed surface pressure disturbance on a uniform stream. Nonlinear, large-amplitude effects are currently under study.

148-08977-030-70

TURBULENT WAKES IN A STRATIFIED FLUID

(*b*) Applied Physics Laboratory, Johns Hopkins University.
(*c*) Dr. Robert K.-C. Chan and Dr. James H. Stuhmiller.
(*d*) Theoretical study.
(*e*) Investigate the dynamics of a general, three-dimensional, statistically steady, turbulent wake in a stably stratified fluid. This project calls for the development of a physical model for anisotropic turbulence and a stable and accurate numerical solution procedure for the coupled system of equations.
(*g*) The fully anisotropic turbulence model leads to predictions which are reasonably compatible with experimental data. The side walls in laboratory experiments are found to significantly influence wake development. The computer pro-

gram WAVEVM (Variable-Mesh Wake Code) is capable of providing accurate solutions for a long-term numerical integration.

(*h*) **Calculations of Turbulent Wakes in a Stratified Fluid,** J. H. Stuhmiller, R. K.-C. Chan, G. T. Phillips, *Rept. POR-3604*, Appl. Phys. Lab., Johns Hopkins Univ., 1974.

148-08978-060-18

INTERNAL WAVE STUDY

(*b*) Defense Advanced Research Projects Agency.
(*c*) Dr. James A. Young or Dr. Robert K.-C. Chan.
(*d*) Theoretical study.
(*e*) Develop a combined numerical and analytic solution method for the accurate determination of the internal wave system related to the passage of a submerged body.
(*g*) The marching technique for flow field near the body has produced results in good agreement with laboratory data. Continued research to predict the far-field wave system using an analytic technique is in progress.

SCRIPPS INSTITUTION OF OCEANOGRAPHY, University of California, San Diego, P. O. Box 1529, La Jolla, Calif. 92037. Dr. Charles S. Cox.

149-09033-450-00

RESEARCH IN THERMAL AND HALINE MICROSTRUCTURE IN THE OCEAN

(*e*) Continuing research which involves studies of the three-dimensional structures down to 1 cm scale sizes. Research is carried out by means of free-fall probes launched from shipboard and recording in-situ.
(*h*) **Measurements of the Oceanic Microstructure of Temperature and Electrical Conductivity,** M. C. Gregg, C. S. Cox, *Deep-Sea Res.* **18,** pp. 925-934, 1971.
Oceanic Microstructure, C. S. Cox, *EOS* **52,** 6, 1971.
Oceanic Fine Structure, T. R. Osborn, C. S. Cox, *Geophys. Fluid Dynam.* **3,** pp. 321-345, 1972.
The Vertical Microstructure of Temperature and Salinity, M. C. Gregg, C. S. Cox, *Deep-Sea Res.* **19,** pp. 355-376, 1972.
Vertical Microstructure Measurements in the Central North Pacific, C. S. Cox, M. C. Gregg, P. W. Hacker, *J. Phys. Oceanog.* 3(4), pp. 458-469, 1973.

149-09034-060-00

LABORATORY STUDIES OF THE COLLAPSE OF TURBULENCE IN STRATIFIED FLUID

(*d*) Experimental; Ph.D. thesis.
(*e*) The study was carried out in a flume with water stratified by salt. The collapse of turbulence was followed as functions in instability and turbulent energy input.
(*h*) Paper in press.

149-09035-450-00

STUDIES OF THE OCEANIC MIXED LAYER

(*e*) Initial studies of part of an on-going program called NORPAX to study the interaction of ocean and atmosphere mainly for the long-term effects. An initial experiment carried out in February 1974 studied the evolution and structure of the mixed layer over horizontal scales of 200 km and extending for three weeks. Measurements included velocity, trajectories and temperature and salinity.

UNIVERSITY OF SOUTH CAROLINA, Marine Science Program, Columbia, S. C. 29208. Dr. F. John Vernberg, Director.

151-09728-400-36

CIRCULATION OF THE NORTH INLET ESTUARY, SOUTH CAROLINA

(*b*) Environmental Protection Agency.
(*c*) Dr. Björn Kjerfve.
(*d*) Field investigation; applied research.
(*e*) Extensive current, water elevation, temperature, salinity, wind velocity, and atmospheric pressure measurements to describe and classify this type of estuary. This hydrographic investigation is interphased with a large scale systems model of the energy flow in the North Inlet marsh and estuary.

UNIVERSITY OF SOUTHERN CALIFORNIA, Department of Aerospace Engineering, University Park, Los Angeles, Calif. 90007. Dr. John Laufer, Department Chairman.

152-09177-020-54

LABORATORY STUDIES OF A TURBULENT, STRATIFIED SHEAR LAYER.

(*b*) National Science Foundation.
(*c*) Frederick K. Browand, Senior Research Associate.
(*d*) Experimental, basic research.
(*e*) The mixing layer is formed by merging two streams of different velocity and density. The purpose is to study the effect upon the turbulence of a statically stable density difference, with application to mixing in the ocean and atmosphere.

152-09178-010-26

GENERATION OF TURBULENCE IN THE TRANSITION OF A LAMINAR BOUNDARY LAYER

(*b*) Air Force Office of Scientific Research.
(*c*) Professor Richard E. Kaplan.
(*d*) Experimental and theoretical, applied research.
(*e*) Predictions and measurements of the location and nature of boundary layer transition.
(*g*) See publications below.
(*h*) **The Intermittently Turbulent Region of the Boundary Layer,** R. E. Kaplan, J. Laufer, *Proc. 12th Intl. Cong. Appl. Mech.*, Stanford Univ., Aug. 26-31, 1968; Springer, 1969.
Spatial Structure in the Viscous Sublayer, A. K. Gupta, J. Laufer, R. E. Kaplan, *J. Fluid Mech.* **50,** p. 493, Dec. 14, 1971.
Statistical Characteristics of Reynolds Stress in a Turbulent Boundary Layer, A. K. Gupta, R. E. Kaplan, *Physics of Fluids* **15,** 6, June 1972.
Intermittent Structures in Turbulent Boundary Layers, R. E. Kaplan, J. Laufer, Symp. volume for AGARD Specialist Mtg. on *Turbulent Shear Flows, AGARD-CP-93*, Technical Editing and Reproduction Ltd., London, 1972.

152-09179-010-54

RESEARCH ON BOUNDARY LAYERS

(*b*) National Science Foundation.
(*c*) Dr. John Laufer.
(*d*) Experimental, basic research; Master's and Doctoral theses.
(*e*) Experimentally determine the large scale and wall structure of the turbulent boundary layer.
(*g*) Both the outer and inner regions of the turbulent boundary layer have been studied by multiple hot-wire and hot-film anemometer probes and by a mild heating of the wall. The measurements were analyzed on a digital computer by the techniques best described as conditional sampling, and Hodograph plane joint probability densities and Lindeberg

statistics. Much novel information about the nature of these structures has been found including their spatial geometry and evolution; the entrainment mechanisms; the statistics of the wall streaks; deep penetration of outer, poorly mixed fluid; and wall bursts. Additionally, experiments in artificial driving of disturbances have been performed with little success.

(*h*) See Project 152-09178-010-26 above.

152-09180-450-54

INTERNATIONAL SOUTHERN OCEAN STUDIES: LABORATORY MODELING STUDIES OF THE ANTARCTIC CIRCUMPOLAR CURRENT

(*b*) National Science Foundation.
(*c*) Professor Tony Maxworthy.
(*d*) Experimental, basic research, for Doctoral thesis.
(*e*) Basic experimental study of rotating flows with and without stratification that are important in the study of ocean circulations. For the A.C.C. the constricting effect of the Drake Passage and other topographical features has been emphasized.
(*g*) The Drake Passage geometry has been found to greatly affect the circumpolar flow and accounts for the majority of the energy dissipation in the whole system.
(*h*) *Proc. 10th Ann. Mtg., Soc. Engrg. Sci.*, Raleigh, N. C., 1972.

152-09181-010-14

RESEARCH ON WALL TURBULENCE

(*b*) U. S. Army Research Office – Durham.
(*c*) Ron Blackwelder, Assistant Professor.
(*d*) Experimental, basic research; Master's and Doctoral theses.
(*e*) Experimentally determine the large scale and wall structure of the turbulent boundary layer.
(*g*) See Project 152-09179-010-54 above.
(*h*) **Pressure Perturbation of a Turbulent Boundary Layer,** R. F. Blackwelder, H. H. W. Woo, *Phys. Fluids* **17**, 3, Mar. 1974.

152-09182-000-54

THE DYNAMICS OF CONCENTRATED VORTICES

(*b*) National Science Foundation.
(*c*) Professor Tony Maxworthy.
(*d*) Experimental, basic research, for Doctoral thesis.
(*e*) Experimental investigation of vortex rings, thermals and aircraft wakes in stratified and unstratified environments, using laser Doppler and photographic techniques.
(*g*) See publications below.
(*h*) **Turbulent Vortex Rings,** T. Maxworthy, *J. Fluid Mech.* **64,** pp. 227-239, 1974.
The Motion of Aircraft Trailing Vortices, T. Maxworthy, *J. Appl. Mech.* (to be published).
On the Motion of Turbulent Thermals, M. P. Escudier, T. Maxworthy, *J. Fluid Mech.* **61,** pp. 541-552, 1973.
On the Dynamics of Turbulent Thermals, Mohamed Gad-El-Hak, Abstract, *Bull. Amer. Phys. Soc.* **19,** 10, Paper CB6, Nov. 1974.

152-09183-020-20

LARGE SCALE STRUCTURE AND ENTRAINMENT IN THE TURBULENT MIXING LAYER

(*b*) Office of Naval Research, Project SQUID.
(*c*) Frederick K. Browand, Senior Research Associate.
(*d*) Experimental, basic research.
(*e*) Additional sampling techniques are applied to the two-dimensional mixing layer to isolate and study the large-scale structure. Work should provide understanding of the basic nature of turbulent mixing and entrainment.

UNIVERSITY OF SOUTHERN CALIFORNIA, Foundation for Cross-Connection Control and Hydraulic Research, School of Engineering, University Park, Los Angeles, Calif. 90007. Professor E. Kent Springer, Foundation Director.

153-00049-860-73

FOUNDATION FOR CROSS-CONNECTION CONTROL RESEARCH

(*b*) Sustaining membership of Local, State and Federal health and water agencies as well as Provincial health and water agencies in the U. S. and Canada.
(*d*) Experimental laboratory and field investigations; basic and applied research; sponsored and theses (M.S., Engr., and Ph.D.).
(*e*) Evaluation of various backflow prevention devices under both laboratory and field conditions. The laboratory contains parallel circuits for all pipe sizes up through 16 inch with capabilities of 4500 gpm at 300 ft head. A parallel system permits the calibration of all normal sizes of water meters. The laboratory is equipped for the training and certification of backflow device testers. This same training and certification program is also available to areas removed from the laboratory by arrangement.
(*g*) Standarized laboratory and field evaluation procedures as well as minimum design and operating specifications have been established for back-flow prevention due to cross-connections. Greatly expanded recognition of the cross-connection control problem by Local, State, Federal and Provincial agencies as well as manufacturers has brought this work of protecting the potable water supply into sharp focus. A major contribution of this program has been the development of the five-day short course and the one-day seminars given both at the Foundation and at agency sites to aid water and health agencies to cope with this cross-connection control problem.
(*h*) **Manual of Cross-Connection Control,** 5th Edition.
Specifications for Back-Flow Prevention Devices, 74.
Cross Talk, a quarterly publication of development news pertaining to cross-connection control.
List of Approved Backflow Prevention Devices. Published several times per year as changes in the "List" occur.

SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE, School of Engineering and Technology, Department of Engineering Mechanics and Materials, Carbondale, Ill. 62901. Philip K. Davis, Department Chairman.

154-08992-020-00

TURBULENT MIXING LAYER IN A CONDUIT

(*c*) Dr. Sedat Sami, Professor.
(*d*) Experimental, basic research, Master's thesis.
(*e*) Velocity and pressure fields downstream from a slot placed normal to the flow in a conduit; investigation of the integral scales of turbulence within the shear layer; reattachment length of the separation streamline.
(*g*) Low pressure zones were found to be closely correlated to zones of high turbulence; the position of the reattachment point depends on the characteristics of the upstream boundary layer and the Reynolds number of the flow; the main features of the ducted shear layer are different than those observed in free-shear layer flows with an ever-expanding mixing zone. In the vicinity of a reattachment-stagnation point the scale of the turbulence decreases. The mean eddy scales appear to be divided in two.
(*h*) **Investigation of a Confined Mixing Layer,** W. H. Liu, *M.S. Thesis*, SIU-C Library, 1973.
On the Three-Dimensional Structure of a Confined Turbulent Shear Layer, *Proc. 4th Canad. Congr. Appl. Mech.*, pp. 743-744, 1973.
Confined Shear Layer Approaching a Stagnation Point, *Proc. 14th Midwestern Mech. Conf., Developments in Mechanics* 8, 1975 (in press).

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SOUTHWEST RESEARCH INSTITUTE, 8500 Culebra Road, P. O. Drawer 28510, San Antonio, Tex. 78284. H. Norman Abramson, Vice President, Engineering Sciences.

155-08274-540-50

ANALYSIS OF PROPELLANT FEEDLINE DYNAMICS

(*b*) National Aeronautics and Space Administration, Marshall Space Flight Center.
(*c*) J. L. Holster, Senior Research Engineer.
(*d*) Theoretical and experimental; applied research.
(*e*) Provide an accurate and easily used dynamic model, and an associated computer program, which represents a typical propellant feedline.
(*f*) Completed.
(*g*) A generalized analytical model and computer program have been developed to predict the frequency response of arbitrary liquid propellant feedline designs. The analytical model is based on an extension of an existing distributed parameter representation of a viscous fluid transmission line with laminar flow which was modified to include the effects of a turbulent mean flow. The effects of dissolved ullage gases, wall elasticity, localized gas or vapor bubbles, bellows, forced changes in length due to structural excitation, complex side branches, and structural mounting stiffness are also included. Each line component is written as a four-terminal, pressure-flow relationship in matrix form in the Laplace domain; the transfer function relating the pressure response at the line terminal (inducer inlet) to the external excitation is obtained in the computer program by sequential matrix substitution.
(*h*) SwRI Final Contractor Report **Analytical Model for Liquid Rocket Propellant Feedline Dynamics,** J. L. Holster, W. J. Astelford; also, *AIAA J. Spacecraft and Rockets* **11**, pp. 180-187, Mar. 1974.
Liquid Rocket Propellant Feedline Dynamics, J. L. Holster, *AIAA Paper 73-1286*.

155-09299-340-70

STUDIES OF EARTHQUAKE-INDUCED FLUID MOTIONS IN ANNULAR RESERVOIRS

(*b*) General Electric Nuclear Power Division.
(*c*) Mr. Robert J. McCaffery, Senior Research Engineer.
(*d*) Experimental and theoretical; applied research.
(*e*) Experimental and analytical studies of earthquake-induced wave motions in the shallow, annular "suppression pool" reservoir of typical nuclear reactors.
(*g*) Both vertical and horizontal earthquake motions are simulated, using a two degree-of-freedom shake table. Various methods of damping the wave motions are also under investigation.

155-09300-110-70

STUDIES OF LIQUEFIED NATURAL GAS (LNG) MOTIONS IN PARTIALLY FULL TANKS

(*b*) Methane Tanker Service.
(*c*) Dr. Robert L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Experimental; applied research.
(*e*) Experimental determination of wave-impact pressures on tank walls.
(*g*) Scale-model studies using liquids with various physical properties, realistic tank geometries, and tank motions were conducted to determine correlating equations for wall pressures in full-scale tanks.

155-09301-620-70

SQUEEZE FILM DAMPERS FOR HIGH-SPEED ROTATING MACHINERY

(*b*) Union Carbide Nuclear Company.
(*c*) Dr. Franklin T. Dodge, Sr. Research Engineer.
(*d*) Analytical; applied research and development.
(*e*) Analytical investigation of hydrodynamic squeeze film dampers for flexible, high-speed rotors.

155-09302-190-50

UNCONFINED VAPOR EXPLOSIONS

(*b*) National Aeronautics and Space Administration, Lewis Research Center.
(*c*) Dr. W. E. Baker, Institute Scientist, and Dr. R. A. Strehlow, University of Illinois.
(*d*) Applied research; theoretical and experimental.
(*e*) Assess damage potential of unconfined vapor explosions and other non-ideal explosions; determine energy released by back-calculations from measured pressure-time histories.
(*g*) A survey of damage mechanics and scaling relationships for non-ideal explosions has been completed. An analysis, using the method-of-characteristics, has been developed to determine the entire flow field and the energy flows resulting from a non-ideal explosion, using experimental pressure-time histories at one location. Calculations of the energy release and flow fields of bursting glass spheres under high pressure are underway to evaluate equivalent TNT yields of non-ideal explosions.
(*h*) **The Characterization and Evaluation of Accidental Explosions,** R. A. Strehlow, W. E. Baker (to be submitted).

155-09303-000-50

FLUID MECHANICS, THERMODYNAMICS, AND HEAT TRANSFER EXPERIMENTS IN SPACE

(*b*) National Aeronautics and Space Administration, Lewis Research Center,
(*c*) Dr. F. T. Dodge, Senior Research Engineer.
(*d*) Basic research.
(*e*) Determine meritorious experiments in fluid mechanics, thermodynamics, and heat transfer that must be conducted in space but have results applicable to earth-bound phenomena.
(*f*) Completed.
(*g*) An overstudy committee of nine members from university and research institute engineers and scientists was formed. Many experiments were identified and evaluated. The impact of a space laboratory environment on the conduct of the experiments was assessed.
(*h*) **Fluid Mechanics, Heat Transfer, and Thermodynamics Experiments for a Space Laboratory,** F. T. Dodge, H. N. Abramson, S. W. Angrist, I. Catton, S. W. Churchill, R. J. Mannheimer, S. Ostrach, S. H. Schwarts, J. V. Sengers, *NASA CR-134742*, (submitted to Science).

155-09304-050-15

CHARACTERISTICS OF HIGH-SPEED COMBUSTING JETS

(*b*) U. S. Army Ballistic Research Laboratory.
(*c*) Dr. F. T. Dodge, Senior Research Engineer.
(*d*) Theoretical; applied research.
(*e*) Studies of combusting jets issuing from tanks of compressed LPG.
(*g*) Using literature results and original analyses, predictions of the flow characteristics of highly-underexpanded two-phase jets of reacting LPG are being made. The heat transfer to insulated steel plates, placed at various distances from the jet orifice, are computed, with the eventual aim of reducing the "torching" hazard in LPG tank car derailments.
(*h*) SwRI Contractor Reports.

155-09305-740-00

FINITE-ELEMENT METHODS FOR FLUID MECHANICS

(*b*) SwRI Internal Research Panel.
(*c*) Dr. F. T. Dodge, and Mr. P. A. Cox, Senior Research Engineers.
(*d*) Theoretical; basic research.
(*e*) Use of finite-element methods to analyze various potential flows with a free surface and environmental flow problems and to extend the usefulness of the method.

155-09306-640-00

FLUID-SHOCK PHYSICS

(*b*) SwRI Internal Research Panel.
(*c*) Dr. F. T. Dodge, Senior Research Engineer.
(*d*) Theoretical; applied research.
(*e*) Explore various techniques of predicting shock or blast-wave interactions with structures or other flow fields.

155-09307-540-50

GAS FLOW INDICATOR FOR PORTABLE LIFE SUPPORT SYSTEMS

(*b*) National Aeronautics and Space Administration, Johnson Spacecraft Center.
(*c*) Dr. R. L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Experimental; developmental research.
(*e*) Development of gas flow indicator to monitor astronauts' oxygen flow.
(*g*) The portable life support system for astronauts uses a ventilation flow sensor to monitor the oxygen loop-flow to the space suit and to actuate an audible warning circuit when the flow rate drops below a critical level. An improved flow sensor is being developed for use in the astronaut's back-pack. The sensor will be capable of triggering an alarm at any predetermined flow rate over a wide range of suit pressures. The instrument is being designed to be insensitive to moisture and vibration with an expected life of 100 mission cycles.

155-09308-530-21

UNSTEADY LOADS ON CAVITATING HYDROFOILS

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. R. L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Theoretical research.
(*e*) Theoretical analysis of unsteady loads on cavitating hydrofoils including the effects of cavity initiation location.
(*f*) Completed.
(*g*) A general numerical approach using a doublet lattice source representation for the prediction of unsteady loads on cavitating, general plan form, finite aspect ratio hydrofoils was conducted. Comparisons for both super- and partial-cavitating foils of high aspect ratio to two-dimensional results exhibited excellent agreement. Low aspect ratio results compared favorably with existing numerical approaches for supercavitating hydrofoils. Additional results for partially cavitating low aspect ratio hydrofoils were presented.
(*h*) **Doublet Lattice Source Method for Calculating Unsteady Loads On Cavitating Hydrofoils,** J. F. Unruh, R. L. Bass, *J. Hydronautics* **8,** 4, pp. 146-153, Oct. 1974. Final SwRI Technical Report.

155-09309-550-22

WATERJET DUCT HYDRODYNAMICS

(*b*) Surface Effect Ships Project Office, Dept. of the Navy.
(*c*) Mr. J. L. Holster, Senior Research Engineer.
(*d*) Theoretical and experimental; applied research.
(*e*) Conduct analytical and experimental studies of the hydrodynamic performance of waterjet duct systems used in high-speed surface effect ships.
(*f*) Completed.
(*g*) Experimental and analytical studies were conducted to determine the hydrodynamic performance of bend diffusers, flow splitters, and other waterjet ducting components, including the effects of uniform and distorted inlet flows. Mechanization requirements for the waterjet duct systems were also evaluated.
(*h*) Final SwRI Contractor Report.

155-09310-550-22

WATERWHEEL TEST FACILITY FOR SURFACE EFFECT SHIPS SEAL FINGER PERFORMANCE STUDIES

(*b*) Surface Effect Ships Project Office, Department of the Navy.
(*c*) Dr. R. L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Experimental applied research and test facility design.
(*e*) Design of a large-scale waterwheel to provide high-speed hydrodynamic free surface testing.
(*g*) Hydrodynamic problems of propulsion, stability, and seakeeping on surface effect ships employing flexible bow and stern seals are secondary compared to seal service life shortcomings. Seal service life is adversely affected by wear and fatigue incurred in normal SES operation, and the relatively short service life of the seals is a major limiting factor in SES design and operation. To gain additional information for improving seal life, large scale test facilities are needed to monitor seal life in realistic environmental and operating conditions. A paper study was performed to determine the feasibility of utilizing a large-scale waterwheel as a test facility for measuring SES seal failure modes and fatigue service life. The operational and design requirements of such a facility have been established and the design of a waterwheel test rig for determining lower seal wear is currently underway.
(*h*) SwRI Contractor Reports.

155-09311-550-21

SKIRT FLUTTER ON SURFACE EFFECT TAKE-OFF LANDING CRAFT

(*b*) Naval Research and Development Center, Department of the Navy.
(*c*) Dr. Robert L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Experimental applied research.
(*e*) Experimental study using scale models of air-cushion landing systems to establish conditions leading to skirt flutter and vibration.
(*f*) Completed.
(*g*) Experimental results indicated that the air-cushion skirt will flutter when the velocity in the gap between the skirt and the ground reaches a sufficient magnitude. Flutter threshold velocities were found to vary with bag pressure, bag geometry, bag flow rate, and the geometry of the surface over which the bag is placed. As a result of the experimental studies, operating conditions that minimize the potential of skirt flutter have been determined.
(*h*) Final SwRI Contractor Report.

STANFORD UNIVERSITY, Departments of Applied Earth Sciences and Geology, Stanford, Calif. 94305. Professor Irwin Remson.

156-08979-810-54

HYDROLOGIC MODELS FOR LAND-USE MANAGEMENT

(*b*) National Science Foundation.
(*d*) Theoretical research with field applications; applied research; M.S. and Ph.D. theses.
(*e*) Development of deterministic and optimization computer models of subsurface hydrology for use in studying and managing watershed hydrology.
(*g*) List of papers available on request.

ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA, Mississippi River at Third Avenue, S. E., Minneapolis, Minn. 55414. Director.

Inquiries concerning Projects 00111, 01168, and 07677 should be addressed to Fred W. Blaisdell, Research Investigations Leader, Soil and Water Conservation Research Division, Agricultural Research Service, St. Anthony Falls Hydraulic Laboratory, at the above address. Inquiries concerning Project 00194 should be addressed to John V. Skinner, Engineer in Charge, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory at the above address.

Inquiries concerning all other projects should be addressed to Director, St. Anthony Falls Hydraulic Laboratory, at the above address.

57-0166W-320-47

ESIGN TO CONTROL EROSION IN ROADSIDE DRAINAGE CHANNELS

For summary, see Water Resources Research Catalog **9**, 2.0621.

57-0170W-340-75

IODEL STUDY OF INTAKE AND DISCHARGE STRUCTURES FOR ZION NUCLEAR STATION

For summary, see Water Resources Research Catalog **9**, 5.0900.

57-0172W-810-33

IATHEMATICAL SIMULATION OF A LARGE WATERSHED USING THE SYSTEMS APPROACH TO QUANTITY AND QUALITY ANALYSIS

For summary, see Water Resources Research Catalog **8**, 6.0736.

57-0280W-810-33

ORECASTING RAINFALL AND SNOWMELT FLOODS ON UPPER MIDWEST WATERSHEDS

For summary, see Water Resources Research Catalog **8**, 2.0819.

157-0281W-060-36

MIXING AND DISPERSION AT A WARM WATER OUTLET

For summary, see Water Resources Research Catalog **9**, 2.0624.

157-0282W-350-75

HYDRAULIC MODEL STUDIES OF SPILLWAY STRUCTURE, NADER SHAH PROJECT, IRAN

For summary, see Water Resources Research Catalog **9**, 8.0216.

157-0283W-350-75

HYDRAULIC MODEL STUDIES OF THE ACARAY RIVER DEVELOPMENT – YGUAZU DAM

For summary, see Water Resources Research Catalog **9**, 8.0220.

157-0284W-870-60

HYDRAULIC MODEL STUDIES OF SEWER TRANSITION TESTS

For summary, see Water Resources Research Catalog **9**, 8.0218.

157-0285W-800-33

COMPUTER PROGRAMS AND SIMULATION MODELS IN WATER RESOURCES: SCOPE AND AVAILABILITY

For summary, see Water Resources Research Catalog **9**, 2.0623.

157-0286W-810-15

A DESIGN ORIENTED CONTINUOUS SYNTHESIS MODEL

For summary, see Water Resources Research Catalog **8**, 8.0294.

157-0287W-800-60

DULUTH GABBRO PILOT STUDY – WATER AVAILABILITY

For summary, see Water Resources Research Catalog **9**, 6.0490.

157-0288W-870-65

STUDY OF FLOW IN VERTICAL DROPSHAFTS – CHICAGO TUNNEL AND RESERVOIR PLAN

For summary, see Water Resources Research Catalog **9**, 8.0217.

157-0289W-350-70

TACONITE DIKE STUDY

For summary, see Water Resources Research Catalog **8**, 8.0299.

157-0290W-870-75

PIG'S EYE MAIN INTERCEPTOR DIVERSION STRUCTURE

For summary, see Water Resources Research Catalog **9**, 8.0223.

157-0291W-340-65

MAYFIELD POWERHOUSE HYDRAULIC MODEL STUDIES

For summary, see water Resources Research Catalog **9**, 8.0222.

157-0292W-350-75

HYDRAULIC MODEL STUDIES OF SPILLWAY STRUCTURE, CERRON GRANDE PROJECT, EL SALVADOR

For summary, see Water Resources Research Catalog **9**, 8.0221.

157-0293W-340-73

MODEL STUDIES OF MOISTURE SEPARATOR REHEATER DRAIN SYSTEM

For summary, see Water Resources Research Catalog **9**, 8.0219.

157-00111-350-05

CLOSED CONDUIT SPILLWAY

(*b*) Agricultural Research Service, U. S. Dept. of Agric., in cooperation with the Minnesota Agric. Expt. Sta. and the St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental; generalized applied research for development and design.
(*e*) Recent work has been a model test of a closed conduit spillway to determine the reasons for and means of correcting its observed undesirable performance. The objectional performance was the drawing of the reservoir level below the spillway crest and sudden depriming.
(*g*) The theory of closed conduit spillways has been developed, verified, and published. Results of tests on many forms of the closed conduit spillway entrance have been published. Pipe culverts laid on steep slopes may flow completely full even though the outlet discharges freely. Generalized methods for analysis and reporting of the results have been developed. The use of air as the model fluid has been verified by comparing test results with those obtained using water as the model fluid. The two-way drop inlet with the horizontal anti-vortex device causes the spillway to act as a self-regulating siphon when the headpool level approximates the anti-vortex plate elevation. The height of the anti-vortex plate above the drop inlet crest and the overhang of the anti-vortex plate determine the effectiveness of the plate as an anti-vortex device. For one form of the inlet, tests have been made to determine the crest loss coefficient, the barrel entrance loss coefficient, the pressures on the plate and the drop

inlet, the general performance of the inlet, minimum and maximum permissible plate heights, and the head-discharge relationship for plate control. Variables have been the length of the drop inlet, the barrel slope, the height and overhang of the anti-vortex plate, and the sidewall thickness. Tests of low-stage orifices in the two-way drop inlet have shown that improper location and improper proportioning of the orifices can prevent priming of the spillway. The proper location and size of the orifices have been determined. To supplement the experiments, potential flow methods have been used to determine the theoretical coefficient of energy loss at the crest of the two-way drop inlet. Six shapes of elbow between the two-way drop inlet and the transition were tested. The elbows were evaluated on the basis of high minimum relative pressures and the presence of adverse pressure gradients. The theoretical free streamline elbow had small areas of adverse pressure gradient. The best elbow is an ellipse with semi-major and semi-minor axes of 2D and 1D. (D is the barrel diameter.) An elbow made up to two 45-degree circular segments of radii D/2 and 3D/2 also has generally satisfactory hydraulic characteristics. Seven transitions between the half-square crown, half-circular invert cross section at the elbow exit and the circular barrel were tested. The best transition is warped and 1D long. (See 1968 issue for details, – ed.) The entrance loss coefficients are low and identical within the limits of experimental precision for all elbow-transition combinations. Tests on the hood drop inlet have shown that the hood barrel entrance can be used to reduce the minimum required height of the drop inlet. Minimum sizes of drop inlet and anti-vortex devices have been determined. Undesirable performance of an operating spillway was traced to air-entraining hydraulic jumps in the barrel, inadequate size and debris-plugged air vents, and delayed venting from under the cover plate skirts that extended below the spillway crest. Adequate venting corrected the undesirable performance. This was achieved by removing a manhole cover in the cover plate. The manhole opening required an antivortex device and a trashrack.

(*h*) The following reports and papers are in various stages of completion:
Hydraulics of Closed Conduit Spillways – Part XIII. The Hood Drop Inlet; Part XIV. Antivortex Walls for Drop Inlets; Part XV. Low-Stage Inlet for the Two-Way Drop Inlet; Part XVI. Elbows and Transitions for the Two-Way Drop Inlet; Part XVII. The Two-Way Drop Inlet With a Semicylindrical Bottom.
Hydraulic Model Investigation of Marsh Creek Dam Principal Spillway, Contra Costa County, California; Theory of Flow in Long Siphons; The Hood Inlet Self-Regulating Siphon Spillway; The Two-Way Drop Inlet Self-Regulating Siphon Spillway.
Hydraulics of Closed Conduit Spillways, Part XII: The Two-Way Drop Inlet With a Flat Bottom, C. A. Donnelly, G. G. Hebaus, F. W. Blaisdell, Agric. Res. Service, U. S. Dept. of Agric., *ARS-NC-14*, 66 pages, Sept. 1974. Copies of the report may be obtained from the Agric. Res. Service, St. Anthony Falls Hydraul. Lab., at the above address.

157-00194-700-10

A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS (Inter-Agency Sedimentation Project in cooperation with St. Anthony Falls Hydraulic Laboratory)

(*b*) Committee on Sedimentation, Water Resources Council; personnel of the U. S. Army Corps of Engrs. and the U. S. Geological Survey are actively engaged on the project.
(*d*) Experimental; applied research and development.
(*e*) Develop equipment and procedures to facilitate both the collection and analysis of sediment transported by natural streams. The project develops sampling equipment to meet special requirements then, as a service to all governmental organizations and to educational institutions, stocks, calibrates, and repairs sampling and analyzing equipment. Major equipment items stocked for resale include a single stage sampler, 4-, 22-, and 62-pound depth integrating samplers, 100-, 200-, and 300-pound electrically operated point-integrating samplers, and an intermittent pumping-type sampler. For the collection of bed material the project stocks piston-type hand operated samplers, 30-, and 100-pound scoop-type samplers. For particle size analysis the project can supply bottom-withdrawal tubes and visual-accumulation sedimentation tubes complete with recorders. New commercially-developed equipment is evaluated on a demand basis. Long-range objective is to develop an instrument to automatically record the concentration of suspended sediment transported by natural streams.
(*g*) A new light-weight suspended sediment sampler has been developed to facilitate sampling of ice covered streams. To improve the quality of depth-integrated samples, a small transit rate pacer was also designed and is now in production. To facilitate laboratory measurement of sediment concentration, a sensitive bulk-density device was built and evaluated. A modification of the falling-drop technique for measuring sediment concentration was also evaluated. Anisole has been used by previous investigators, but unfortunately the chemical is toxic. With a special instrument oil substituted for Anisole, the resolution was found to be about 200 mg/liter. A modified automatic-tracking device for the visual accumulation tube was developed and a working model of a special automatic pipette for size analysis was constructed. Tests on the ISCO pumping sampler and Pi-M-C particle size analyzer are currently underway. In cooperation with ASTM the group is assisting with preparation of standard procedures for sediment sampling.
(*h*) **A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams, Report U, An Investigation of a Device for Measuring the Bulk Density of Water-Sediment Mixtures,** J. P. Beverage, J. V. Skinner, 35 pages, Aug. 1974. A catalog and numerous progress and letter reports are available upon request. Contact the District Engineer, St. Paul District, Corps of Engineers, 1135 U. S. Post and Custom House, St. Paul, Minn. 55101.

157-01168-350-05

A STUDY OF CANTILEVERED OUTLETS

(*b*) Agricultural Research Service, U. S. Dept. of Agric. in cooperation with Minnesota Agric. Expt. Sta. and St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental; generalized applied research for design.
(*e*) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts are being made to determine quantitatively the size of the scour hole to be expected under various field conditions. Rectangular cantilever outlets with a deflector at the exit to throw the water away from the structure and move the scour hole further downstream are also scheduled for investigation.
(*g*) Analysis of the results obtained in the last two years is just beginning.

157-06744-040-54

FREE STREAMLINE FLOW OVER DISCONTINUITIES IN A BOUNDARY LAYER

(*b*) National Science Foundation.
(*d*) Theoretical and experimental; Doctoral thesis.
(*e*) Study was directed toward understanding the mechanism of cavity formation on a boundary subjected to low pressure under the influence of free surface and gravity force. The analytical work involved the development of a non-linear free-streamline theory with gravity force included. Experiments were made to measure the cavity properties in open channels at supercritical and subcritical flow conditions.
(*f*) Completed.
(*g*) The analysis shows, and the experiment confirms, that the cavity characteristics vary discontinuously at the critical Froude number. For example, when the Froude number is

increased from slightly less than one to slightly greater than one, the cavity length may more than double. The cavity shape also changes abruptly at the critical Froude number.

(*h*) **Gravity and Free Surface Effect on a Fully Cavitating Flow,** *Ph.D. Thesis*, Univ. of Minnesota. To be published in *J. Fluid Engrg., ASME.*

157-07661-060-20

WAVES IN STRATIFIED FLUIDS

(*b*) Office of Naval Research, Dept. of the Navy.
(*d*) Experimental and analytical.
(*e*) An experimental facility was developed wherein progressive waves of specified characteristics in stratified fluid could be produced.
(*f*) Completed.
(*g*) An image method capable of representing internal waves in a finite depth stratified fluid was developed. Unlike the image method for the potential flows, the basic image system for a stratified fluid requires three columns of wave making singularities. The theory and experiment agree well on the characteristic wave length, the ratio of the wave length to the depth of the fluid, and the wave speed.
(*h*) **Generation of Internal Waves in Stratified Fluids,** C. C. S. Song, J. Hwang, St. Anthony Falls Hydraul. Lab., *Project Rept. No. 144*, June 1973.

157-07677-220-05

SCOUR AND PROTECTION AGAINST SCOUR AT STRUCTURES

(*b*) Agricultural Research Service, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expmt. Sta. and the St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental; generalized applied research for development and design.
(*e*) Determine the need for protective riprap, the area requiring protection, and the size of riprap required at the inlet and outlet of a box inlet drop spillway proposed for Tillatoba Creek, Yazoo River Watershed, Tallahatchie County, Miss.; and laboratory studies to determine for the box inlet drop spillway, the straight drop spillway, and the SAF stilling basin, the size and shape of the scour in sand beds and the size and placement of riprap to protect against scour.
(*f*) Suspended.
(*g*) A compound trapezoidal weir was developed for the box inlet drop spillway to choke the spillway crest and insure bank full channel flow at the spillway for bank full channel capacity flow. This will prevent the overbank flow from eroding the channel banks when it returns to the channel near the spillway. The procedure described in National Cooperative Highway Research Program Report 108 was used to design the riprap size and placement upstream of the spillway crest and eliminate the 14-foot deep by 105-foot wide by 50-foot long scour of the original sand bed. The initial design, based on measured velocity contours with the flow approaching the spillway, proved to be completely satisfactory. Downstream of the spillway a riprap blanket 9 inches thick of 3-pound median and 9-pound maximum size stone provided adequate protection where the channel shape closely approximated the self-scoured shape. In contrast, a blanket 36 inches thick of 36-pound median and 780-pound maximum size riprap was required over a larger area to protect the channel from scour when the riprap encroached on the self-scoured channel shape.
(*h*) **Model Test of Box Inlet Drop Spillway and Stilling Basin Proposed for Tillatoba Creek, Tallahatchie County, Miss.,** F. W. Blaisdell, Agric. Res. Service, U. S. Dept. of Agric., *ARS-NC-3*, 50 pages, Jan. 1973. Copies of the report may be obtained from the Agric. Res. Serv., St. Anthony Falls Hydraul. Lab., at the above address.

157-08289-230-20

NEW INSTRUMENTATION FOR THE MEASUREMENT OF THE CAVITATION SUSCEPTIBILITY OF WATER

(*b*) Office of Naval Research.
(*d*) Applied research, experimental and analytical.
(*e*) The cavitation performance in terms of the number of cavitation events per second of a standard, analytically derived body may be related to the nuclei size distribution entrained in the test fluid and interpreted as an indication of the cavitation susceptibility of the fluid. The research was directed at finding this relationship.
(*f*) Completed.
(*g*) A technique has been developed for characterizing the cavitation susceptibility of water. It is based on physically counting cavitation events near inception as a function of cavitation number using a standard body. The nuclei are represented by a distribution of equivalent gas bubbles. Standard bodies are designed using potential flow theory so that the bubble trajectories, along with the bubble cavitation rates, can be calculated. By calculating cavitation events for various bubble densities and size distributions and comparing the results with measured data for the same body, it is possible to infer the specifications for the equivalent bubbles.
(*h*) **The Use of Standard Bodies to Measure the Cavitation Strength of Water,** E. Silberman, F. R. Schiebe, E. Mrosla, *St. Anthony Falls Hydraul. Lab., Proj. Rept. 141*, Sept. 1973.
A Method for Determining the Relative Cavitation Susceptibility of Water, E. Silberman, F. R. Schiebe, *Proc. Conf. on Cavitation*, Heriot-Watt Univ., Inst. of Mech. Engrs., 3-5 Sept. 1974 (to be published).

157-08290-250-20

RISING BODY TEST FACILITY FOR THE INVESTIGATION OF THE EFFECTS OF DRAG REDUCING POLYMERS ON FLOW NOISE, DRAG, AND SURFACE PRESSURE FLUCTUATION

(*b*) Office of Naval Research, Department of the Navy.
(*d*) Experimental applied.
(*e*) The construction of a rising body test facility is expected to be useful in the measurement of drag, surface pressure fluctuations, and radiated noise from test bodies in relative motion with a liquid. The rising body test facility was chosen as a configuration with a minimum of moving parts to cause extraneous noise and vibration which at the same time provides the possibility of a relatively simple hydrodynamic form for a test body.
(*f*) Terminated.
(*g*) A rising body test facility was completed and preliminary tests showed performance nearly as expected.
(*h*) **A Buoyancy-Propelled Test Body Laboratory Facility,** J. M. Killen, *St. Anthony Falls Hydraul. Lab., Proj. Rept. 149*, June 1974.

157-08291-250-54

FLOW MECHANISM OF THE ZERO-CROSSING RATE FOR LOCAL SHEAR MEASUREMENTS IN FLOWING FLUID

(*b*) National Science Foundation.
(*d*) Experimental.
(*e*) Examine in detail the physical processes involved in the correlation of a zero-crossing rate of heat transfer fluctuations from hot-film probes with relevant flow properties in shear flows. The problem of shear (drag) reduction by polymer additives to water will be studied as a test case.
(*f*) Completed.
(*g*) Extensive measurements were made of the relationship of zero-crossing rate of shear fluctuations in an air pipe to higher Reynolds numbers than were previously used. Usefulness of technique for shear measurements was found limited to Reynolds numbers less than 1.2×10^{-6} in air. No such limitation was observed in water. Correlation maps of shear and u' components were taken. Some work was also conducted in water and in drag reducing polymers.

(*h*) **A Preliminary Report on the Zero-Crossing Rate Technique for Average Shear Measurement in Flowing Fluid,** J. M. Wetzel, J. M. Killen, *St. Anthony Falls Hydraul. Lab. Proj. Rep. 134*, Nov. 1972.

157-08305-720-21

FEASIBILITY AND MODEL STUDY OF 36-INCH WATER TUNNEL

(*b*) Naval Ship Research and Development Center, Dept. of the Navy.
(*d*) Feasibility study based on old and new experimental studies.
(*e*) Establish a feasible preliminary design for a large variable pressure, free-surface, high speed hydrodynamic test facility.
(*f*) Completed.
(*g*) Study led to construction and test of 1/5 scale model of proposed facility. Free surface test stream of high quality can be generated at velocities to 95 fps in a horizontal test section 7.5 inches square. Pressure controls cavitation number and gravity separator removes entrained air.
(*h*) **A Hydrodynamic Feasibility Study for a Large, High-Speed, Variable Pressure, Free Surface Water Test Facility,** J. F. Ripken, J. M. Wetzel, F. R. Schiebe, *St. Anthony Falls Hydraulic Lab. Memo M-132*, 91 pages, Apr. 1972.
Hydrodynamic Studies for a Large, High Speed, Variable Pressure, Free Surface Flow Facility, J. F. Ripken, J. M. Wetzel, L. M. Bergstedt, *St. Anthony Falls Hydraul. Lab. Memo M-134*, 122 pages, Aug. 1973.
The St. Anthony Falls Hydraulic Laboratory High Speed, Variable Pressure, Free Surface Flow Facility, J. F. Ripken, J. M. Wetzel. To be presented at *14th ITTC*, Ottawa, Sept. 1975.

157-08993-300-05

HYDRAULICS OF ALLUVIAL CHANNELS – CHANNEL STABILITY AS RELATED TO CHANNELIZATION

(*b*) Agricultural Research Service in cooperation with the St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental and theoretical.
(*e*) The factors which lead to instability in river channels are being studied. Particular attention is being given to the processes of meandering and braiding, and to the hydraulic conditions necessary for the establishment of a channel of stable width. Experimental work is being conducted in initially straight model sand rivers, which are freely allowed to erode their banks and develop meandering or braided channels. The problem is also being investigated theoretically using, for example, stability analysis. The processes being studied in the laboratory are relevant in estimating the stability of channelized streams.
(*g*) The data obtained from these experiments are being combined with other laboratory and field data in order to test some theoretical developments. Preliminary results include new criteria for dividing river morphology into straight, meandering, and braided regimes, a critique of various methods for estimating meander length and an extension of tractive force theory to the case where stable banks coexist with sediment load.
(*h*) **On the Cause and Characteristic Scales of Meandering and Braiding in Rivers,** *J. Fluid Mechanics*.

157-08994-300-54

INVESTIGATION OF MEANDER SYSTEMS WITH SPECIAL REFERENCE TO THE DISCHARGE SPECTRUM

(*b*) National Science Foundation.
(*d*) Experimental and theoretical, Ph.D. thesis.
(*e*) Study is a continuation of a previous investigation conducted to ascertain the influence of the significant variables on the development of meander systems. Detailed measurements will be made of the time development of meanders, to follow the development of the meander system in time.

157-08995-870-73

STUDY OF COOLING WATER DISCHARGE EFFECTS ON WINTER CONDITIONS IN MINNESOTA

(*b*) Electric Utilities Group.
(*d*) Field investigation and analysis.
(*e*) Investigations are being made to evaluate the effects of warm water discharges on winter conditions in rivers and lakes with emphasis on Minnesota conditions and on actual and potential beneficial effects. Studies to date indicate that the presence of open water areas on the Mississippi River is directly related to cooling water input, and that this open water advances the date of ice-free conditions on the river by several weeks. Further studies to verify results to date are planned.

157-08996-210-54

THE MECHANISM OF TURBULENCE IN STEADY HELICAL PIPE FLOW

(*b*) National Science Foundation.
(*d*) Experimental, basic, Ph.D. thesis.
(*e*) An experimental study of the basic mechanics of turbulence and turbulent shear stress distribution in flow in helically corrugated pipes is being carried out. Measurements will be used to relate velocity profiles and friction factors to turbulence characteristics and to study the properties of three-dimensional boundary layers. The experimental work was conducted in a 12-inch diameter helical pipe using air as the fluid and hot-film anemometer equipment was used to measure turbulent fluctuations, energy spectra and shear stress in the flow.
(*f*) Being completed under laboratory sponsorship. Nearly all experimental work in the facility is now completed and analysis of data is underway.

157-08997-480-44

STOCHASTIC ANALYSIS OF METEOROLOGICAL DATA IN THE UPPER MIDWEST

(*b*) National Oceanic and Atmospheric Administration.
(*d*) Applied research; Doctoral thesis.
(*e*) Provide a stochastic analysis or model of meteorological and hydrological data during the spring flood period in the Upper Midwest for use with digital simulation models. Both the simulation and stochastic models in spring flood prediction will be evaluated on the NWSRFS model.
(*g*) During the first quarter a statistical analysis of temperature and precipitation data at St. Cloud, Minnesota was undertaken. The following resulted: 1) the temperature data were stabilized, 2) it was concluded that temperature and precipitation could be treated as independent variables, 3) the deterministic component of temperature was computed, 4) auto-correlation, partial auto-covariance and spectra of the stochastic component of temperature were computed, 5) parameters of the Markov chain were estimated for each period for precipitation, and 6) the parameters of gamma distribution were estimated.

157-08998-220-47

FILM INVESTIGATION OF THE CAUSES OF FAILURE OF THE BIG SIOUX BRIDGE

(*b*) Federal Highway Administration.
(*d*) Field and laboratory investigation.
(*e*) A training film is being prepared for use by the Federal Highway Administration. It includes footage of an investigation of the causes of failure of the river crossing conducted in the laboratory and field films taken by the Federal Highway Administration after the failure and during a subsequent flood to delineate the flow pattern through the structure. The film will incorporate additional scenes showing the nature of scour around piers, a discussion of the parameters influencing the scour, and illustrate the hydraulic factors that influenced the failure.

157-08999-350-75

STABILITY TESTS OF DAM SEALING MATERIAL

(*b*) Barr Engineering Company, Minneapolis, Minn.
(*d*) Experimental.
(*e*) Materials for the core, filter, and base layers for an earth dam were tested for filter and sealing characteristics. The studies relate to a Bethlehem Steel Company tailings pond to be constructed at Hibbing, Minn.
(*f*) Completed.
(*g*) The tests established the relative usefulness of available materials.
(*h*) **Stability Tests of Dike Sealing Materials for the Bethlehem Steel Company Tailings Pond,** J. F. Ripken, T. L. Pennaz, *St. Anthony Falls Hydraul. Lab. Memo M-135*, 19 pages, Aug. 1974 (not available).

157-09000-430-75

HYDRAULIC MODEL STUDIES OF THAMES RIVER, CONNECTICUT, PIER

(*b*) Sverdrup and Parcel and Associates, Incorporated, St. Louis, Mo.
(*d*) Experimental; applied research, design, operation, development.
(*e*) It is proposed that the St. Anthony Falls Hydraulic Laboratory construct and operate a model of a section of the Thames River and a proposed submarine outfitting pier and typical submarine, collecting and analyzing experimental data to establish optimum wave screening properties of the pier structure for use by the Electric Boat Division.
(*f*) Completed.
(*g*) The proposed pier provides little protection to a submarine against southerly waves. No wave screens attached to the pier could provide meaningful and additional protection on the submarine either. On the other hand, the pier, the submarine, and wave screens were found to provide various degrees of sheltering effect on small boats moored in the area.
(*h*) **Hydraulic Model Study of South Yard Pier and Wave Screens,** C. S. S. Song, *St. Anthony Falls Hydraul. Lab., Proj. Rept. 153*, Nov. 1974.

STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory, Castle Point Station, Hoboken, N. J. 07030. Dr. John P. Breslin, Director.

158-08284-520-22

STUDY OF ADDED SHIP RESISTANCE; APPLICATION OF BI-SPECTRAL ANALYSIS TECHNIQUES

(*b*) Naval Ship Systems Command, General Hydromechanics Research Program.
(*c*) J. F. Dalzell.
(*d*) Experimental and analytical; applied research.
(*f*) Complete.
(*g*) Demonstrate by analyses of experimental data that a postulated quadratic functional polynomial model is a reasonable representation of the added ship resistance produced by waves. The evidence so far produced is fairly strong that this is so, and that the model shows considerable promise as a unifying concept for the analysis and interpretation of added ship resistance in random waves. In the course of the work, cross-bispectral analysis methods were developed and applied to the derivation of or "identification" of the "added resistance operator" from data obtained in irregular waves.
(*h*) **Cross-Bispectral Analysis: Application to Ship Resistance in Waves,** *J. Ship Res.* **18,** 1, pp. 62-72, Mar. 1974.

158-08980-520-21

ANALYSIS OF THE PNEUMATIC-HYDRODYNAMIC EFFECTS ATTENDING OSCILLATORY HEAVING OF SURFACE-EFFECT SHIPS

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. C. H. Kim, Research Engineer and Dr. S. Tsakonas, Chief, Fluid Dynamics Division.
(*d*) Theoretical; applied.
(*e*) Ascertain the relationship between plenum pressure and heave amplitude at any pressure and Froude number. This study will provide essential insight into the role played by lack of pressure scaling, the condition under which all current model testing is conducted.

158-08981-520-21

ANALYSIS OF THE AERODYNAMICS OF THE CHAMBER OF A WATERBORNE AIR CUSHION CRAFT

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Chief, Fluid Dynamics Division and Miss W. R. Jacobs, Senior Research Engineer.
(*d*) Theoretical; applied.
(*e*) Study concerns the air-cushion chamber of ACV craft under the influence of a continuous air supply through a single fan or a pair of fans and leakage of air through a peripheral gap when the vehicle operates near the time-dependent wavy, deformable free surface or executes heaving or pitching motion in calm water. The pressure distribution, as well as forces and moments, are determined by a numerical procedure adaptable to high-speed digital computer.
(*f*) Completed.
(*g*) Davidson Laboratory report is in preparation.

158-08982-530-00

LIFTING SURFACE THEORY AND HYDROELASTIC INSTABILITY

(*c*) Dr. S. Tsakonas, Chief, Fluid Dynamics Division, Miss W. R. Jacobs, Senior Research Engineer, Mr. M. R. Ali, Research Engineer.
(*d*) Theoretical; applied research.
(*e*) A brief review is presented of the unsteady lifting surface theory and of the "generalized lift operator" technique of inverting the downwash integral equation. The integral equation approach is then employed to predict responses of a hydrofoil and various oscillations and forward motion in a regular wave train, as well as of the main hydrofoil of the AG(EH) configuration for which experimental results are available. Removal of the leading edge singularity has been attempted before and after the inversion of the "downwash" integral equation. A set of calculations for the hydroelastic instability has been carried out on the basis of the above results with and without structural damping.
(*f*) Completed.
(*g*) Although removal of the leading edge singularity before the inversion of the integral equation yields unacceptable hydrodynamic results, in contrast, the results of calculations for the boundary of the hydroelastic instability yield conservative predictions when the leading edge singularity is removed before the inversion of the integral equations. By proper selection of the structural damping, agreement between the predicted and experimentally determined instability boundary can be achieved.
(*h*) *Davidson Laboratory Report 1653.*

158-08983-550-21

COUNTER-ROTATING PROPELLERS IN SPATIALLY VARYING THREE-DIMENSIONAL FLOW FIELD DUE TO LOADING AND THICKNESS EFFECTS

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Chief, Fluid Dynamics Division, Miss W. R. Jacobs, Senior Research Engineer, Mr. M. R. Ali, Research Engineer.
(*d*) Theoretical; applied.

(*e*) Linearized unsteady lifting-surface theory has been applied in the study of two interacting counter-rotating propellers when both lifting surfaces of finite thickness operate in non-uniform inflow field. A mathematical model is introduced which represents as realistically as possible the geometry of the propulsive system as well as the three-dimensional spatially varying inflow conditions. The interaction problem leads to a pair of surface integral equations which has been solved by the collocation method in conjunction with the usual mode approach and the so-called "generalized lift operator." The thickness effects have been taken into account by utilizing the "thin body" approach. The computational procedure has been established and a program adaptable to a high-speed digital computer is being developed. The program will furnish information about the steady and unsteady blade loading distribution and the corresponding hydrodynamic forces and moments, which are all vital for the design of this propulsive system.

158-08984-550-21

STEADY AND UNSTEADY BLADE PRESSURE DISTRIBUTIONS DUE TO LOADING AND THICKNESS EFFECTS

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Chief, Fluid Dynamics Division, Miss W. R. Jacobs, Senior Research Engineer, Mr. M. R. Ali, Research Engineer.
(*d*) Theoretical; applied.
(*e*) Improve the computations of steady and unsteady blade pressure distribution of a propeller operating in uniform and non-uniform inflow fields at design and off-design conditions. These distributions will be of great value for prediction of cavitation inception and blade stress analysis.

158-08985-520-54

THEORETICAL AND EXPERIMENTAL RESEARCH ON SHIP MANEUVERABILITY IN SHALLOW WATER

(*b*) National Science Foundation, Engineering Division,
(*c*) Theory: Dr. S. Tsakonas, Chief, Fluid Dynamics Division and Dr. C. H. Kim. Experiment: Dr. H. Eda.
(*d*) Theoretical and experimental; applied research.
(*e*) Improve the understanding of the dependence of several of the significant coefficients in the equations of motion upon hull parameters and water depth and to secure needed shallow water data which cannot be adequately estimated by theory. It is expected to arrive at estimates of motions, stability and maneuverability of a ship advancing at constant speed in shallow water.
(*f*) Completed.
(*g*) The theoretical hydrodynamic coefficients have been evaluated for the Series 60, $C_B = 0.60$ cargo ship model tested at Davidson Laboratory and for the full tanker model tested by Fujino. The theory shows the same trends with depth and with Froude number as do the experiments. There are, however, quantitative discrepancies in the very shallow water region (i.e., depth-draft ratio = h/d = 1.1 to 1.20) but, as this ratio increases, experiments and theoretical results come closer. The discrepancy is largest for the lateral force ratio, Y'_{β}. The comparison of theoretical results with Norbin's experiments, obtained with a larger scale model, shows very good correlation.

158-08986-550-21

UNSTEADY LOAD ON DUCTED PROPELLERS AND NOZZLES DUE TO LOADING AND THICKNESS EFFECTS

(*b*) Naval Ship Research and Development Center.
(*c*) Dr. S. Tsakonas, Chief, Fluid Dynamics Division, Miss W. R. Jacobs, Senior Research Engineer, Mr. M. R. Ali, Research Engineer.
(*d*) Theoretical; applied research.
(*e*) Develop a theoretical approach for determining the unsteady and steady-state blade loading distribution and corresponding hydrodynamic forces and moments exerted on the ducted propeller and its enshrouding nozzle due to loading and thickness effects of both lifting surfaces when operating in a three-dimensional non-uniform flow field.
(*f*) Completed.
(*g*) Theory shows that the inclusion of thickness distribution of both lifting surfaces leaves unchanged the mechanism of interaction which has been established previously, and its effect is rather moderate.
(*h*) *Davidson Laboratory Report 1722.*

158-08987-520-54

AERO- AND HYDRODYNAMIC COUPLING IN SURFACE EFFECT SHIPS

(*b*) National Science Foundation.
(*c*) J. P. Breslin, T. V. Davies, B. Fleischman, R. I. Hires, L. Levine.
(*d*) Analytical; experimental research.
(*e*) Analytical work directed at the determination of the influence of seal stiffness, Froude number and heaving frequency on surface effect ships plenum pressures to be correlated with measurements made on a small scale model in the Davidson Laboratory circulating water channel. Determine the influence of Froude number and heaving frequency on the plenum pressures of surface effect ships.

158-08988-520-22

STUDY OF THE APPLICATION OF THE FUNCTIONAL POLYNOMIAL INPUT-OUTPUT MODEL TO ADDED RESISTANCE IN WAVES

(*b*) Naval Sea Systems Command, General Hydromechanics Research Program.
(*c*) J. F. Dalzell.
(*d*) Analytical, applied research.
(*e*) Attempt synthesis in the time domain of the long period fluctuations of added resistance.

SYRACUSE UNIVERSITY, Department of Civil Engineering, Fluid Dynamics Laboratory, Syracuse, N. Y. 13210. Dr. Wen-Hsiung Li.

159-08308-870-54

DISPERSION OF POLLUTANTS IN TIDAL ENVIRONMENT

(*b*) National Science Foundation.
(*d*) Theoretical study.
(*f*) Completed.
(*h*) **Well-Mixed Estuaries with Nonlinear Resistance,** W.-H. Li, *J. Hydraul. Res.* **12,** 1, 1974.
DO-Sag in Oscillating Flow, W.-H. Li, M. E. Kozlowski, *Proc. ASCE* **100,** EE4, Aug. 1974.
Tidal Flow in Exponentially Varying Estuaries, W.-H. Li, M. E. Kozlowski, *Proc. ASCE* **100,** HY11, Nov. 1974.

TETRA TECH, INCORPORATED, 630 North Rosemead Boulevard, Pasadena, Calif. 91107. Dr. Bernard Le Méhauté, Senior Vice President.

161-09111-410-13

ASSESSMENT FOR BEACH EROSION AND HURRICANE PROTECTION PROJECTS, SOUTH COAST OF LONG ISLAND

(*b*) Corps of Engineers, New York District.
(*d*) Applied research.

161-09112-810-60

MANAGEMENT PLAN FOR ST. LOUIS RIVER BASIN

(*b*) State of Missouri.
(*d*) Applied research.

161-09113-220-13

ENVIRONMENTAL IMPACT OF PROPOSED BEACH AND SHORELINE PROTECTION MEASURES

(*b*) Corps of Engineers, Detroit District.
(*e*) Assessment of shore damage by coastal structures, field investigation of the environmental impact of five Great Lakes harbors on adjacent shores.

161-09114-470-87

MODIFICATIONS TO MASTER PLANS FOR DEEP WATER HARBORS IN ALGERIA

(*b*) Government of Algeria.
(*d*) Applied research.
(*e*) Modifications to master plan for deep water harbor at Arzew, Algeria – engineering and model studies to determine design criteria, breakwater stability, wave agitation, mooring line loading, ship movement and harbor seiching. Modifications to master plan for deepwater harbor at Skidda, Algeria – engineering and model studies to determine design criteria, breakwater stability, wave agitation, mooring line loads, ship movement and harbor seiching.

161-09115-430-88

DEEP SEA MINING PROGRAM

(*b*) Pennaroya Le Nickel, Cnexo, France.
(*d*) Applied research.
(*e*) Design, construction and testing at sea of special instrumentation for mining of manganese nodules, support in preparation of exploratory campaign.

161-09116-510-22

UNDERWATER TRAJECTORY ANALYSIS

(*b*) U. S. Navy Strategic Systems Project Office.
(*d*) Applied research.
(*e*) Analytical defining of 6 degree freedom motion of underwater projectiles with computer program development thereof.

161-09117-510-22

TRAJECTORY COMPUTATION OF UNDERWATER MISSILES

(*b*) U. S. Navy Strategic Systems Project Office.
(*d*) Applied research.
(*e*) Correlation of computer model with full scale experimental data. Behavior of submersibles in an impulsive-generated wave field – mathematical model and wave tank study of the 6 degree freedom motion of submersibles.

161-09118-520-29

SHIP VULNERABILITY TO LARGE WAVES

(*b*) Defense Atomic Support Agency.
(*d*) Applied research.
(*e*) Numerical and hydraulic modeling to determine wave effects on ships.

161-09119-520-29

WATER WAVE EFFECT ON SHIP AND SUBMERSIBLE VESSELS

(*b*) Defense Nuclear Agency.
(*d*) Applied research.
(*e*) Numerical modeling of vessel motions in harbors due to waves generated by disturbances.

161-09120-520-70

SHIP STABILIZER STUDY

(*b*) Santa Fe Drilling.
(*d*) Applied research.
(*e*) Theoretical and experimental study on drilling barge stabilization against roll by use of patented gyro stabilizer.

161-09121-470-65

FEASIBILITY STUDY FOR FISH HARBOR MARINA, LOS ANGELES HARBOR

(*b*) Port of Los Angeles, California.
(*d*) Applied research.
(*e*) Feasibility and engineering assessment of proposed fish harbor marina, with hydraulic scale model study to ensure construction economy and minimize wave agitation.

161-09122-470-65

MASTER PLAN FOR CONTAINER SHIP TERMINAL AT LONG BEACH HARBOR, CALIFORNIA

(*b*) Port of Long Beach, California.
(*d*) Applied research.
(*e*) Field measurements, hydraulic scale model study and computer analysis of feasibility and engineering design criteria for harbor expansion to accommodate large SL-7 ships. Also included is an analysis of the thermal effects of industrial waste cooling water.

161-09123-470-52

RESONANCE AND OSCILLATIONS OF WAVES IN HARBORS OF ARBITRARY SHAPE AND VARIABLE DEPTH

(*b*) Energy Research and Development Administration.
(*d*) Applied research.
(*e*) Computer modeling of harbor resonance; hydraulic lab modeling; prediction of water-wave effects.

161-09124-470-52

HARBOR AGITATION AND ITS EFFECTS ON MOORED SHIPS DUE TO LONG WAVES

(*b*) Energy Research and Development Administration.
(*d*) Applied research.
(*e*) Scale model experiments and computer prediction of harbor seiching and motions of moored ships in a harbor of arbitrary shape and depth. Vulnerability of harbor facilities to nuclear explosion prediction of damage to ships, port structures, power systems, pipe lines from blast shock, thermal radiation, explosion-generated waves. Harbor ship mooring studies – experimental investigation of harbor and moored ship response to waves, experimental study of wave transformation in shallow water.

161-09125-420-20

PREDICTION OF NEARSHORE WAVES AND CURRENTS

(*b*) Office of Naval Research.
(*d*) Applied research.
(*e*) Theoretical investigations of prediction for design waves, breakers, currents and sand transport on ocean coasts.

161-09126-750-11

DEVELOPMENT OF MOVABLE BED SCALE MODEL TECHNOLOGY

(*b*) Corps of Engineers, Coastal Engineering Research Center.
(*d*) Applied research.
(*e*) Development of hydraulic scale model investigation of beach erosion problems for Coastal Engineering Research Center.

161-09127-410-60

SAND MOVEMENT AROUND POINT CONCEPTION, CALIFORNIA

(*b*) State of California.
(*d*) Applied research.
(*e*) Prediction methods for yearly sand movement and tracer technology review.

161-09129-420-22

SHALLOW-WATER WAVE FORECASTING METHODS

(*b*) Naval Training Device Center.
(*d*) Applied research.

(*e*) Development of methods to predict shallow water wave spectra under effects of bottom, wind, wave breaking, etc.

161-09130-450-22

DIFFUSION OF RADIOACTIVE DEBRIS IN THE OCEAN

(*b*) Naval Radiological Defense Laboratory.
(*d*) Applied research.
(*e*) Establishment of prediction model for nuclear debris after release in deepwater.

161-09131-870-36

HEAT DISTRIBUTION IN NUCLEAR POWER PLANT EFFLUENT

(*b*) U. S. Environmental Protection Agency.
(*d*) Applied research.
(*e*) Prediction of heat distribution in the nuclear power plant effluent discharging into large bodies of water – establishment of computer prediction model.

161-09132-870-36

ENVIRONMENTAL IMPACT OF DISPOSAL OF CONCENTRATED WASTE IN THE OCEAN

(*b*) U. S. Environmental Protection Agency.
(*d*) Applied research.

161-09133-860-10

MASTER PLAN FOR WATER SUPPLY MANAGEMENT FOR METROPOLITAN WASHINGTON AREA

(*b*) Corps of Engineers.
(*d*) Applied research.
(*e*) Impact of non-point pollution on water supplies and environmental baseline data summary and analysis for the metropolitan Washington, D. C. area.

161-09134-870-48

OIL SPILL PREDICTION FOR LONG BEACH HARBOR.

(*b*) U. S. Coast Guard and Port of Long Beach, California.
(*d*) Applied research.
(*e*) Establishment of oil spill tracking prediction by both computer modeling and field measurements.

161-09135-860-13

ECOLOGICAL MODELING OF BOISE RIVER, IDAHO

(*b*) Corps of Engineers and State of Idaho.
(*d*) Applied research.
(*e*) Water quality and management master planning for Boise River, Idaho.

161-09136-860-13

WATER QUALITY AND ECOLOGICAL INVESTIGATION OF LAKE SYSTEM

(*b*) Corps of Engineers, Buffalo District.
(*d*) Applied research.
(*e*) Establishment of ecological system prediction in Lake Erie.

161-09137-870-53

POTENTIAL OF OIL SPILL IN GULF OF ALASKA

(*b*) Council on Environmental Quality.
(*d*) Applied research.
(*e*) Assessment of earthquake, tsunami, ice and storm effects on oil spill.

161-09138-420-52

OCEAN WAVE ENVIRONMENTAL IMPACT ESTABLISHMENT FOR SOUTH PACIFIC OCEAN

(*b*) Energy Research and Development Administration.
(*d*) Applied research.

161-09139-870-65

ENVIRONMENTAL IMPACT OF DREDGE AND FILL ON LOS ANGELES FISH HARBOR MARINA

(*b*) Port of Los Angeles, California.
(*d*) Applied research.

161-09140-520-22

HIGH SPEED SURFACE EFFECT SHIP HULL DESIGN

(*b*) Surface Effects Ships Program Office.
(*d*) Applied research.
(*e*) An analytic model for the prediction of typical hulls in high speed SES was developed and verified against model tests. Seal systems for surface effect ships – development of analytic models for the representation of flexible skirt systems for SES. Inlet design for surface effect ships – the analytic and engineering design of typical inlets for waterjet propulsion systems for SES. Surface effect ship design – analytical design and model testing to predict the performance, stability and maneuverability of a 2000 ton SES.

161-09141-470-87

MASTER PLAN FOR DEEPWATER HARBOR FOR LNG TANKERS AT BETHIOUA, ALGERIA

(*b*) Government of Algeria.
(*d*) Applied research.
(*e*) Comprehensive feasibility and engineering studies including design wave and other environmental parameters, breakwater stability and design, basin size and wharfage determination by queueing and agitation analysis, ship mooring facility locations, with hydraulic model experiments.

161-09142-470-87

MASTER PLAN FOR NAVAL BASE EXPANSION AT SAUDI ARABIA

(*b*) Government of Saudi Arabia.
(*d*) Applied research.
(*e*) Investigations for bathymetry, geology, winds, waves, tides and environmental data to assess feasibility of expansion of naval bases at Jubail and Jeddah, Saudi Arabia.

161-09143-860-60

MASTER PLAN FOR BASIN WATER QUALITY MANAGEMENT, SAN DIEGO REGION

(*b*) State of California Water Resources.
(*d*) Applied research.
(*e*) Comprehensive study of oceanographical and marine ecological impacts on San Diego Basin water quality and technical assistance in planning and management.

TEXAS A&M UNIVERSITY, Department of Civil Engineering, College Station, Tex. 77843. Dr. John B. Herbich, Professor and Head, Coastal, Hydraulic and Ocean Engineering Group.

162-07708-410-44

SCOUR OF GULF COAST SAND BEACHES DUE TO WAVE ACTION IN FRONT OF SEA WALLS AND DUNE BARRIERS

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Project.
(*c*) Professor R. E. Schiller, Jr.
(*d*) Experimental, applied research; Master's thesis and Ph.D. dissertation.
(*e*) A series of transient beach scour tests are being carried out on a laboratory wave tank using beach slopes of 1:40, 1:50 and 1:70 to arrive at beach scour profiles under various wave conditions. A computer program is being used in an attempt to measure shallow water wave reflection coefficients.

(*f*) Completed.

Scour of Gulf Coast Beaches Due to Wave Action, C. B. Chesnutt, R. E. Schiller, Jr., *Offshore Technology Conf., Paper No. 1352*, 1971.

Experimental Studies of Beach Scour Due to Wave Action, W. O. Song, *C.O.E. Rept. 166, TAMU-SG-73-211*, Texas A&M Univ., 1973.

162-08311-870-48

AN INVESTIGATION OF THE EFFECTS OF CURRENTS AND WAVES ON A FLOATING OIL SLICK RETAINED BY A BARRIER

(*b*) United States Coast Guard.
(*c*) Dr. L. A. Hale, Dept. of Mech. Engrg., Dr. D. R. Basco, Dept. of Civil Engineering.
(*d*) Experimental, basic and applied research, M.S. and Ph.D. theses.
(*e*) Investigate the individual and combined effects of surface gravity waves and currents on the behavior of an oil slick.
(*f*) Completed.
(*g*) Empirical equations developed to estimate set-up of oil slick by waves only and to predict oil entrainment in currents as a function of oil properties and flow field.
(*h*) **The Effects of Currents and Waves on an Oil Slick Retained by a Barrier,** L. A. Hale, D. J. Norton, C. A. Rodenberger, *USCG, DOT-CG-23327A*, Dec. 1974.

An Investigation of the Effects of Progressive Waves on an Oil Slick Retained by an Absorber Beach, Y.-M. Huang, *M.S. Thesis*, Texas A&M, Aug. 1973.

162-09047-420-13

EFFECTS OF CURRENT ON CHARACTERISTICS OF GRAVITY WAVES

(*b*) Texas A&M University and U. S. Army Engineers Waterways Experiment Station.
(*c*) Dr. J. B. Herbich and Dr. L. Z. Hales.
(*d*) Experimental and analytical research.
(*e*) Changes occur in the characteristics of surface waves propagated in a region of streaming water. The velocity field of the wave motion interacts with the velocity distribution of the current pattern. The effect of the nonuniform current on the rate of energy propagation through the inlet was investigated by combining the results of the experiments with previously developed theoretical work. It was found that under certain specific conditions both flood and ebb currents enabled the waves to propagate more energy through the inlet than in the absence of a current as a result of the interaction of the two velocity fields.
(*f*) Completed.
(*h*) **Effects of a Steady Nonuniform Current on the Characteristics of Surface Gravity Waves,** L. Z. Hales, J. B. Herbich, *Misc. Paper H-74-11*, U. S. Army Engr. Waterways Exp. Station, Dec. 1974.

162-09048-590-22

THREE-DIMENSIONAL RESPONSE OF DEEP WATER LINES IN STEADY STATE FLOWS

(*b*) Naval Facilities Engineering Command.
(*c*) Dr. Richard F. Dominguez, Dept. of Civil Engineering.
(*d*) Theoretical and experimental; applied research.
(*e*) A systematic study of cable parameters in relation to deep water mooring applications under three-dimensional steady state loading conditions has been made. Included in this study are both negatively and neutrally buoyant cables in water depths from 5 to 25 thousand feet. A finite element model cable was used to predict three-dimensional configuration, cable reactions and internal stress distribution in the cable under directional hydrodynamic loading conditions.
(*f*) Completed.
(*g*) A systematic study of various hydrodynamic cable loading models indicated that the choice of loading criteria is rather arbitrary. Results are presented which permit direct evaluation of three-dimensional cable configurations and reactions for cables of arbitrary geometry, diameter and weight in currents up to one knot.
(*h*) **Three-Dimensional Response of Deep Water Mooring Lines in Steady State Flows,** R. F. Dominguez, G. E. Owens, *Texas A&M Univ. Rept. COE-157*, Dec. 1972.

162-09049-590-00

HYDRODYNAMIC FORCES ON CABLES SUBJECT TO FREQUENCY VARIED MOTION

(*c*) Dr. Richard F. Dominguez, Assoc. Professor, Dept. of Civil Engineering.
(*d*) Experimental and theoretical; basic research.
(*e*) The dependency of hydrodynamic forces under unsteady, oscillatory conditions is studied with respect to the behavior of a highly flexible cable subjected to forced motion in a fluid. Experimental investigation is supplemented with the use of a finite element model of a cable structure.
(*g*) Results to date show that significant errors are possible by using classical descriptions based on the steady state derived added mass and drag coefficients for part of the cyclic loading history.
(*h*) **Hydrodynamic Forces on Cables Subject to Frequency Varied Motion,** R. W. Haas, R. F. Dominguez. Presented *16th Cong. Intl. Assoc. Hydraul. Res.*, San Paulo, Brazil, Aug. 1975.

162-09050-220-44

SCOUR AROUND OFFSHORE PIPELINES

(*b*) National Oceanic and Atmospheric Administration.
(*d*) Experimental, applied research; Master's thesis.
(*e*) Determine through physical modeling, the effect of storm waves on buried pipelines approaching and crossing the shoreline. Scour depth and scour patterns have been evaluated in a two-dimensional wave tank and future tests will be conducted in a wave basin to evaluate three-dimensional effects. Analysis of two-dimensional data indicates relationships between scour depth and wave height; scour length and wave length; and wave height and wave length/water depth for a range of wave steepness values.

162-09051-420-44

WAVE INDUCED PRESSURE FIELDS AROUND A BURIED PIPELINE

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Program.
(*c*) Dr. Richard F. Dominguez, Assoc. Professor, Dept. of Civil Engineering.
(*d*) Theoretical and experimental; applied research.
(*e*) Numerical computer models using both the finite difference and finite element technique were developed to simulate the interaction of a two-dimensional wave system with a submerged pipeline and its surrounding soil media. Both computer models were validated by comparison with existing analytical and experimental results defining the pressure distribution in the soil media without a pipeline. Models are being used to study possible liquification failure phenomena and to establish rational criteria for designing offshore pipelines.
(*h*) **Numerical Solutions for Determining Wave-Induced Pressure Distributions Around Buried Pipelines,** N. W. Lai, R. F. Dominguez, Texas A&M Univ., *Sea Grant Rept. TAMU-SG-75-204*, Dec. 1974.

162-09052-490-44

DEVELOPMENT AND ANALYSIS OF COMPUTER MODELS OF HYDRAULIC PIPELINE DREDGE

(*b*) Center for Dredging Studies, Sea Grant (NOAA).
(*c*) Dr. David R. Basco, Associate Professor.
(*d*) Theoretical, applied research.
(*e*) A computer based model of a hydraulic pipeline dredge and system has been developed to study the relative importance of many variables involved (pump design, sediment size, etc.) on the solids output for various pumping distances (horsepower limitation) and digging depths

(cavitation limitation). The model can be used to predict optimum solids production for any given hydraulic-pipeline dredging operation. In addition, problems associated with field studies of hydraulic dredges have been identified and a field research program proposed to obtain field data to validate the results of the computer model.

(*g*) Preliminary comparisons between model-results and limited field data show good agreement. Pump design can be one of the most important variables in output of similar dredges.

(*h*) **Systems Engineering and Dredging – The Feedback Problem,** D. R. Basco, *Sea Grant Publication TAMU-SG-74-204.*

Parameter Study of Variables Affecting the Performance of a Hydraulic Pipeline Dredge Model, D. R. Basco, *Proc. 7th Dredging Seminar, CDS Rept. 181, Sea Grant Rept. TAMU-SG-75, 1975.*

An Experimental and Theoretical Study of the Flow Field Surrounding a Suction Pipe Inlet, W. J. Apgar, D. R. Basco, *Sea Grant Publication TAMU-SG-74-203; Texas A&M Thesis* by W. J. Apgar.

Analytical Model of Hydraulic Pipeline Dredge, D. R. Basco, *J. Waterways, ASCE* **101,** WW1, Feb. 1975.

162-09053-490-00

METHODS FOR OFFSHORE DREDGING

(*b*) Center for Dredging Studies, Texas A&M University.

(*d*) Conceptual design.

(*e*) Conventional, river cutterhead dredges are not designed for operation in open waters under wave conditions. There is a need for development of seaworthy pipeline dredges capable of operating in waves up to 6 feet in height. Several different catamaran twin-hulls are evaluated for possible use to provide a stable platform for offshore dredging.

(*h*) **Methods for Offshore Dredging,** J. B. Herbich, *Proc. 6th World Dredging Conf.*, Taipeh, Taiwan, 1974.

162-09054-370-47

PAVEMENT AND GEOMETRIC DESIGN CRITERIA FOR MINIMIZING HIGHWAY HYDROPLANING

(*b*) Federal Highway Administration, Office of Research and Development.

(*c*) Professor B. M. Gallaway, D. D. L. Ivey, Dr. W. D. Ledbetter, Dr. H. E. Ross, Jr., Dr. R. E. Schiller, Jr., Dr. Don Woods.

(*d*) Study of literature and reanalysis of previous Texas A&M University data on water films, hydroplaning, skid resistance. Use of computer program HVOSM to study vehicle control. Investigation of surface drainage critëria of the various State Highway Departments.

(*e*) A study involving required texture for portland cement concrete pavement surfaces to minimize hydroplaning; partial and full dynamic hydroplaning of vehicle tires; required texture and cross-slope combinations for asphalt concrete surfaces; the relationship of pavement cross slope to vehicle control; the hydraulic flow phenomena of thin films of water on pavement surfaces and under tires; and deficiencies in existing surface drainage design methodology for sag vertical curves.

(*f*) Phase I part of study to be completed in April 1975. Phase II to start Spring 1975.

(*g*) Phase I, draft submitted to project sponsor. Revised final report, Phase I to be submitted April 1975.

(*h*) **Pavement and Geomatrice Design Criteria for Minimizing Highway Hydroplaning, Phase I, Final Report,** *Federal Highway Admin. Rept. No. FHWA-RD-74*, Office of Res. and Dev., Washington, D. C. 20590, about July 1975.

162-09055-220-44

INVESTIGATIONS OF THE SPREAD AND EROSION OF UNCONFINED DREDGE SPOIL MOUNDS

(*b*) NOAA, Sea Grant Program; Corps of Engineers, Office of Dredged Material Research.

(*c*) Dr. David R. Basco, Assoc. Professor.

(*d*) Field and analytical, applied research, M.S. and Ph.D. theses.

(*e*) A field investigation was conducted to determine the rate and extent of spread of unconfined, maintenance (silt) material in Galveston Bay, Texas, adjacent to the Gulf Intracoastal Waterway (GIWW). A review of previous dredging histories (quantities, locations, times, etc.) is also in progress together with a study of the local environment in an attempt to identify the sources of sediment contributing to shoaling problems in the waterway. It is desired to develop the capability to predict the rate at which dredged material, placed adjacent to dredged channels, will return to the channel due to gravity spreading, local currents and wind and wave erosion of the material. This information is desired to assess spoil disposal alternatives on a sound economic basis. Additional field studies and hydraulic model, sediment transport investigations are planned to correlate time scales for spoil island erosion between field and hydraulic model results.

(*g*) In the completed field study in Galveston Bay, immediately following deposition, over 40 percent of the spoil left the designated spoil area and spread out over the bay floor primarily as a mud-density current. Eventually spoil covered an area three-times larger than the original spoil area. Return of the spoil to the newly dredged channel was not significant during the study period primarily because of the presence of a submerged dike along the channel and the tidal direction.

(*h*) **Field Study of an Unconfined Spoil Disposal Area of the GIWW in Galveston Bay, Texas,** D. E. Bassi, D. R. Basco, *Sea Grant Rept. TAMU-SG-74-208; Texas A&M M.S. Thesis*, D. E. Bassi.

Assessment of the Factors Controlling the Long-Term Fate of Subaqueous Spoil Banks, D. R. Basco, A. H. Bouma, W. A. Dunlap, Army Corps of Engrs. Contract. No. C-0129, Jan. 1975.

162-09056-030-00

THE EFFECT OF VISCOSITY ON THE DYNAMICS OF A SUBMERGED SPHERICAL SHELL

(*c*) Dr. Jack Y. K. Lou, Dept. of Civil Engineering.

(*d*) Theoretical; basic.

(*e*) The axisymmetric vibrations of a spherical shell immersed in a compressible, viscous fluid are studied. The dynamic response of the shell is determined by the classical normal mode method while a boundary layer approximation is employed for the fluid medium.

(*g*) It is found that for free oscillation, fluid viscosity may produce noticeable effects on the damping components of the complex natural frequencies and is particularly important for the non-radiating modes. For forced vibrations, the present study reveals that the contribution of viscous effect is of small order, except in the vicinity of peak shell responses.

(*h*) **The Effect of Viscosity on the Dynamics of a Submerged Spherical Shell,** T.-C. Su, Y. K. Lou, presented *Vibrations Conf., ASME*, Sept. 17-19, 1975.

162-09057-220-44

IMPROVEMENTS IN DESIGN OF DIKED DREDGE SPOIL DISPOSAL BASINS

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Program.

(*c*) Dr. David R. Basco, Assoc. Professor.

(*d*) Experimental applied research, M.S. and Ph.D. theses.

(*e*) Hydraulic model study of general settling tank characteristics of typical diked dredge spoil disposal basin was conducted using tracer injection and dispersion curve technique. Various modifications of the inlet design were tested to improve basin operation as a sedimentation tank. Resulting, non-dimensional dispersion curves combined with quiescent column settling curves to derive estimates of sediment removal rates for any type of input material. Field investigations of a similar design planned for 1975-76.

(g) Baffling improved the tank performance over the conventional, plain-end entrance pipe. A single baffle centrally placed in front of the inlet pipe proved superior to the other inlets tested. Increasing the water depth also yielded significant improvements in behavior.
(h) **A Dispersion Curve Study of Model Dredge Spoil Basins,** R. Male, D. R. Basco, *Sea Grant Rept. TAMU-SG-75-201; Texas A&M Thesis*, R. Male.

62-09058-420-00

FORCES DUE TO WAVES ON SUBMERGED STORAGE TANKS

(d) Experimental and analytical research.
(e) The existing theories describing wave forces on large submerged structures have been reviewed. Inertial forces are predominant on submerged structures which have the principal dimension equal to or larger than the vertical dimension. Wave forces on model submerged structures were determined experimentally and results for geometrically simple structures were obtained.
(h) **Wave Forces on Underwater Storage Tanks,** J. B. Herbich, P. Versowsky, *IEEE Intl. Conf. Engrg. in the Ocean Environment*, Halifax, Nova Scotia, Aug. 1974.
Forces Due to Waves on Submerged Structures, J. B. Herbich, G. E. Shank, *Proc. ASCE*, Feb. 1971.
Wave Forces on Submerged Model Structures, P. E. Versowsky, J. B. Herbich, *Offshore Tech. Conf.*, Dallas, Tex., 1974.

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TEXAS A&M UNIVERSITY, Texas Water Resources Institute, College Station, Tex. 77843. Dr. J. R. Runkles, Institute Director.

163-0294W-800-33

MODELING AND SENSITIVITY ANALYSIS OF THE OPTIMAL EXPANSION OF WATER RESOURCES SYSTEMS

(b) OWRR.
(c) Dr. D. M. Himmelblau, Dr. William G. Lesso, Univ. Texas, Austin, Tex. 78712.
(e) See WRRC 9, 6.0943.

163-0295W-860-33

EFFECTS OF ORIGINAL VEGETATION ON RESERVOIR WATER QUALITY

(b) OWRR.
(c) Dr. John Ball.
(e) See WRRC 9, 5.1558.

163-0296W-870-33

NITROGEN MASS BALANCE DETERMINATION FOR SIMULATED WASTEWATER LAND-SPREADING OPERATIONS

(b) OWRR.
(c) Dr. R. M. Sweazy, Dr. D. M. Wells, Texas Tech. Univ., Lubbock, Tex. 79409.
(e) See WRRC 9, 5.1592.

163-0297W-860-33

NETWORK FLOW MODELING OF MULTI-RESERVOIR DISTRIBUTION SYSTEMS

(b) OWRR.
(c) Dr. Paul A. Jensen, Univ. Texas, Austin, Tex. 78712.
(e) See WRRC 8, 2.1212.

163-0298W-860-33

WATER QUALITY CRITERIA FOR RECLAIMED WASTEWATERS AS AN URBAN DOMESTIC WATER SUPPLY

(b) OWRR.
(c) Dr. Harold W. Wolf, Dr. Ted M. Sparr.
(e) See WRRC 8, 3.0447.

163-0299W-840-33

INCREASED WATER USE EFFICIENCY THROUGH TRICKLE IRRIGATION

(b) OWRR.
(c) Dr. Edward A. Hiler.
(e) See WRRC 9, 3.0320.

163-0300W-810-33

VARIATION OF URBAN RUNOFF QUALITY AND QUANTITY WITH DURATION AND INTENSITY OF STORMS – PHASE III

(b) OWRR.
(c) Dr. Dan M. Wells, Dr. Robert M. Sweazy, Texas Tech. Univ., Lubbock, Tex. 79409.
(e) See WRRC 9, 4.0199.

163-0301W-800-33

ALTERNATIVE SOLUTIONS FOR WATER RESOURCE DEVELOPMENT: A CASE STUDY

(b) OWRR.
(c) Dr. David R. Basco.
(e) See WRRC 8, 6.1242.

163-09059-700-33

INSTRUMENTATION FOR ENGINEERING MANAGEMENT OF A MULTI-PURPOSE RIVER BASIN SYSTEM

(b) OWRR.
(c) Dr. Earnest F. Gloyna, Univ. Texas, Austin, Tex. 78712.
(e) The goal of this project was to determine the conceptual requirements of future data acquisition and monitoring instrumentation systems for the efficient operation and management of a highly developed river basin system. The Trinity River Basin in Texas is selected as an example system for specific recommendations. The complexity of the entire Trinity River system is evaluated and the feasibility of using a real-time data acquisition system on the Trinity River and its tributaries is considered. The current state-of-the-art in management instrumentation is evaluated to ascertain the extent of practical feasibility and applicability on both the micro- and macro-scale environments, i.e., the Dallas-Fort Worth area and the entire Trinity River Basin, respectively.
An algorithm was developed for finding the optimal management policies for the dynamic operation of a system of multipurpose reservoirs, tertiary wastewater treatment plants, wastewater retention basins, and navigation locks and dams. This management procedure is designed to interface with a real-time water quality monitoring system so that operating policies can be adjusted to reflect changing environmental conditions.
(h) **Instrumentation for Engineering Management of a Multi-Purpose River Basin System (Trinity River Basin, Texas) – Real-Time Engineering Management of a Multi-Purpose River Basin System,** E. F. Gloyna, W. G. Lesso, Q. W. Martin, *CRWR-98*, Center for Research in Water Resources, Univ. of Texas at Austin, Dec. 1973.

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UNIVERSITY OF TEXAS AT AUSTIN, Center for Research in Water Resources, Balcones Research Center, Austin, Tex. 78758. L. R. Beard, Technical Director.

164-09060-310-07

DOWNSTREAM EFFECTS OF FLOODWATER DETENTION STRUCTURES

(b) U. S. Soil Conservation Service.
(c) L. R. Beard, Center for Research in Water Resources, or W. L. Moore, Professor, Dept. of Civil Engineering.
(d) Theoretical; applied research.

(*e*) Research is now in progress to give a quantitative evaluation of downstream effects of floodwater detention structures. A systematic procedure will be developed for evaluating the effects of changes in seepage, evaporation and transpiration on the net inflow to a reservoir and for determining the effects of storage structures on the quantity and timing of flows at the furthest downstream point in each of several SCS study areas. Also, the effects on flows will be determined at more remote points downstream of one or more study areas.

164-09061-800-33

TECHNIQUE FOR PROJECTING ALTERNATIVE FUTURES FOR WATER RESOURCES PLANNING

(*b*) OWRT and Water Resources Council.
(*d*) Theoretical; basic research.
(*e*) Develop one or more techniques for projecting into the future variables pertinent to water resources planning in such a way that all important possibilities are adequately considered. Such techniques will produce a set of projections for each variable that adequately represent the range of probabilities and stochastic characteristics of that variable. An additional goal of this project is to increase the reliability of frequency estimates of natural flood flows and, through delineation of comprehensive flood-frequency estimation procedures, to increase the uniformity of flood frequency estimates made by different agencies.

164-09062-300-13

SYSTEM REGULATION PROCEDURES FOR THE ARKANSAS RIVER, OKLAHOMA

(*b*) Southwestern Division, Corps of Engineers.
(*c*) L. R. Beard, Center for Research in Water Resources, or W. S. Butcher, Professor, Dept. of Civil Engineering.
(*d*) Operation; Masters thesis.
(*e*) A simulation and evaluation study will be performed of the Arkansas River system under present operation rules for 21 or more years of record. Necessary data will be obtained to study the seasonal variation of flood potential, flood-control requirements, power potential and requirements, navigation needs and recreation needs. After these items have been studied for seasonal variation, critical areas will be delineated for further study. A determination of the critical times, locations and interactions of the variables will be made by examining the results of the simulation and evaluation computations. Then techniques will be developed for modifying operation criteria and improving operation rules and recommend new operation criteria for the Arkansas River system above Van Buren.

164-09063-310-44

TECHNIQUE FOR EVALUATING FLASH FLOOD POTENTIAL AND WARNING CAPABILITY

(*b*) National Weather Service, National Oceanic and Atmospheric Administration.
(*d*) Applied research.
(*e*) One or more techniques are to be developed for systematically evaluating flash flood potential on the basis of meteorological and drainage basin characteristics, type of flood problem and basic data availability. Considering various sources of information and services available, a routine procedure will be developed and, to the extent feasible, computerized for application to large numbers of locations throughout the United States.

UNIVERSITY OF TEXAS AT AUSTIN, College of Engineering, Department of Civil Engineering, Austin, Tex. 78712. Dr. Walter L. Moore.

165-02162-810-30

HYDROLOGIC STUDIES, WALLER CREEK WATERSHED

(*b*) Cooperative with U. S. Geological Survey.
(*d*) Field investigation; applied research.
(*e*) Measurements of rainfall and runoff for a 4-square mile and a 2-square mile portion of the Waller Creek watershed are being made to provide basic information for estimating runoff from small urban watersheds in the Southwest area. Two stream flow stations and a rain gage net are in operation. Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin are being made by various proposed methods to serve as a base comparison with the data as it is collected.
(*g*) Data has been collected since 1956 by the U.S.G.S. and for later years is available in special reports listed below. Data has been used in a number of hydrologic studies and its use will continue.
(*h*) **Compilation of Hydrologic Data, Waller and Wilbarger Creeks, Colorado River Basin, Texas 1966,** Geological Survey, Water Resources Division, Austin, Tex.

165-05456-810-15

MATHEMATICAL MODELS FOR RELATING RUNOFF TO RAINFALL

(*d*) Master's and Doctoral research based on computer analysis and field data.
(*e*) Starting with the Stanford Watershed Model a revised procedure for numerical simulation of watershed hydrology was developed with emphasis on providing a more realistic simulation of infiltration and soil moisture movement. Most recently the simulation program is being used to investigate the effect of lawn watering on runoff on the Waller Creek Watershed in Austin, Texas, where both rainfall and artificial watering support lawn growth. The program is being used to see if the higher level of soil moisture maintained by lawn watering affects the amount of runoff from natural rainfall and thereby compensates to some extent for water used for lawn irrigation. Also some comparisons are made between a few measured soil moisture measurements and simulated values of the soil moisture.
(*g*) Current results show some increase in simulated runoff when lawn irrigation is included, indicating a compensating effect.
(*h*) **Numerical Simulation of Watershed Hydrology,** in *Systems Approach to Hydrology, Proc. Bi-Lateral Seminar on Hydrology*, Water Resources Publications, Fort Collins, Colo., 1971.
Numerical Simulation of Watersheds Using Physical Soil Parameters, *Proc. 13th Cong. Intl. Assoc. Hydraul. Res.* **1**, pp. 211-220, Aug.-Sept. 1969.

165-05457-360-60

A NEW TYPE ENERGY DISSIPATOR FOR CULVERT OUTLETS

(*b*) Texas Highway Dept. and U. S. Bureau of Public Roads.
(*d*) Experimental and theoretical thesis work.
(*e*) Study of a culvert energy dissipator based on the use of a sector of a circular hydraulic jump. Apparent advantages of the device are the stability of the jump over a range of discharge and tailwater conditions and the opportunity to spread the culvert discharge back to the original stream width. Problems of practical geometry have been explored and initial designs developed for a structure that performs well for a considerable range of tailwater conditions. The structure is adaptable for use either at the outlet of a box culvert or a circular pipe culvert.
(*f*) Inactive.
(*h*) **Design Aspects and Performance Characteristics of Radial Flow Energy Dissipators,** W. L. Moore, K. Meshgin, *Research Report 116-2F*, Center for Highway Res., Aug. 1970.

165-05459-420-00

FINITE-AMPLITUDE GRAVITY WAVES

(*c*) Dr. L. R. Mack, Dept. of Engrg. Mechanics.
(*d*) Theoretical; basic research.
(*e*) Our previously published treatment breaks down for very small values of the depth-to-wave-length ratio; this break-

down is now recognized as a singular perturbation problem. Appropriate stretching of the vertical coordinate and the depth parameter facilitates use of the method of matched asymptotic expansions to obtain a valid solution for small depth. Velocity, surface configuration, and frequency of oscillation have been obtained.

(*h*) **Standing Gravity Waves of Finite Amplitude in Liquid of Small Depth,** L. R. Mack, C. D. Hill, in press.

165-06180-440-73

TEMPERATURE FIELDS IN STRATIFIED RESERVOIRS

(*b*) Texas Electric Service Company.
(*d*) Applied research; laboratory investigation.
(*e*) The temperature and velocity field in a stratified reservoir have been studied by use of a generalized laboratory model, 8 ft long, 1 ft wide, and 2 ft deep. In the laboratory model factors may be varied, such as the temperature and amount of heated inflow, location of inflow, location of outflow, heat input through surface radiation, and wind shear at the surface. The temperature field and its change with time was measured by 100 thermistors located at selected points throughout the model. The velocity patterns were measured by observing and photographing the motion of dye streaks. The results indicate a thermocline development generally as expected by a reversing flow direction in alternate layers which appears to be related to multiple jets observed by others in experiments with continuously stratified flow and in axially directed flow in a rotating fluid.
(*f*) Completed.
(*h*) **A Laboratory Investigation of Temperature and Velocity Fields in a Vertical Section Through a Circulating Cooling Reservoir,** *Tech. Rept. HYD 17-7201*, Hydraulic Engrg. Lab., Feb. 1972.

165-07722-000-00

LAMINAR FLOW BETWEEN ROTATING CONCENTRIC SPHERES WITH HEAT TRANSFER

(*c*) Dr. L. R. Mack, Dept. of Engrg. Mechanics.
(*d*) Theoretical; basic research.
(*e*) Velocity and temperature fields of viscous fluid enclosed between two coaxially rotating concentric spheres of different temperatures. Solution completed for case of inner sphere having nonuniform temperature.
(*f*) Completed.
(*h*) **Thermal Effects on Slow Viscous Flow Between Rotating Concentric Spheres,** T. A. Riley, L. R. Mack, *Intl. J. Nonlinear Mech.* **7**, pp. 275-288, 1972.

165-08313-860-33

OPTIMAL OPERATION OF A COMPLEX URBAN WATER SYSTEM

(*b*) Office of Water Resources Research.
(*c*) Dr. Walter L. Moore and W. S. Butcher (Office of Science and Technology, Executive Office of the President, Washington, D. C.).
(*d*) Theoretical and field investigation; applied research, Ph.D. dissertation.
(*e*) Conjunctive operation of ground and surface waters offers considerable economies by regarding the water supply as a system. This project will examine the opportunities for conjunctive operation, using the San Antonio system as an example, and develop optimum operating procedures for this conjunctive system which will consist of ground and surface water and possibly, include, if appropriate, use of surplus storm runoff and possible substitution of wastewaters for other waters. This optimal operation study will explore the use of the various tools of systems analysis for this particular problem. Stochastic dynamic programming, linear programming, and simulation, all will be considered; and the optimal operating policy will be developed using one or more of these techniques.
(*h*) **Optimal Operation of Multi-Reservoir Water Resources Systems,** A. Sundar, *Ph.D. Dissertation*, Aug. 1973.

165-08314-430-00

FLOATING BREAKWATER DESIGN

(*c*) Dr. Walter L. Moore.
(*d*) Experimental; applied research; Master's or Doctoral thesis.
(*e*) Active investigation was started in 1970 of a new concept for a floating breakwater. The breakwater minimizes the required anchoring forces and the amplitude of the transmitted wave by causing the wave forces on different parts of the structure to balance one another. Two sets of reflecting surfaces are arranged so the offset between them can be adjusted to approximately one-half wave length for the range of incident waves anticipated at the site. Tests have indicated good performance in monochromatic waves, and preliminary results in wind generated waves look promising. A patent on the invention has been applied for.
(*h*) **The Performance of An Offset Breakwater Configuration in Wind Generated Waves,** E. D. Sethness, Jr., C. D. Sabathier, W. L. Moore, *Conf. Floating Breakwaters*, Univ. of R. I., Kingston, R. I., Apr. 23-25, 1974.
Applications of An Offset Floating Breakwater Configuration, J. E. Daily, W. L. Moore, W. D. Sethness, Jr., *Offshore Tech. Conf.*, Houston, Tex., May 6-8, 1974.
The Performance of An Offset Breakwater Configuration in Wind Generated Waves, E. D. Sethness, Jr., *M.S. Thesis*, Feb. 1973.
Anchor Forces Exerted by Offset and Box Floating Breakwaters, D. D. Engle, Jr., *M.S. Thesis*, Sept. 1974.

165-09065-870-00

PREDICTION OF COOLING POND RESPONSE TO WASTEWATER INFLOWS

(*b*) Bureau of Engineering Research.
(*c*) James E. Daily, Asst. Professor of Ocean Engrg., Dept. of Civil Engineering.
(*e*) In water-short areas such as South Texas, an attractive possibility for improving stream quality and or supplying anticipated cooling water requirements of electric power plants is direct flow of wastewater effluents to cooling ponds. Feasibility of direct inflows depends on algae buildup with subsequent condenser fouling and the quality of water discharged from ponds to natural streams. Objective of the research is to develop a predictive ecological model of cooling pond response to wastewater inflows. Quantitative prediction of algae buildup and discharge water quality by this model will enable accurate assessment of wastewater inflow feasibility.

165-09066-470-60

LOW COST BUOY BARRIERS FOR BOAT RAMP PROTECTION

(*b*) State of Texas, Parks and Wildlife Department.
(*c*) James E. Dailey, Asst. Professor of Ocean Engrg., Dept. Civil Engineering.
(*e*) At state boat ramp facilities, waves created by passing ships or sudden storms occasionally create uncontrollable situations for boatmen launching or recovering their boats. To reduce the risk of personal injury and property damage, the feasibility of using commercially available plastic shapes to erect a barrier which will dissipate the energy of wave action is being studied. A comparatively low-cost barrier is sought which can be installed easily in the field, using minimum manpower and equipment.

165-09067-410-54

ESTABLISHMENT OF OPERATIONAL GUIDELINES FOR TEXAS COASTAL ZONE MANAGEMENT

(*b*) National Science Foundation, Research Applied to National Needs Program, Office of the Governor, State of Texas, Division of Planning Coordination.
(*c*) James E. Dailey, Asst. Professor of Ocean Engrg., Dept. of Civil Engineering, or E. G. Fruh. See WRRC 9, 6.0941.

UNITED AIRCRAFT CORPORATION RESEARCH LABORATORIES, 400 Main Street, East Hartford, Conn. 06108. Dr. R. G. Meyerand, Jr.

166-08315-000-00

NUMERICAL STUDY OF SEPARATION BUBBLES

(*c*) Dr. W. R. Briley.
(*d*) Theoretical; applied research.
(*e*) Computations of the flow field in the vicinity of two-dimensional laminar, transitional and turbulent separation bubbles are being made using an implicit finite-difference method for solving the incompressible, time-dependent, Navier-Stokes equation. The turbulence model being used is based on an integral form of the time-dependent turbulence kinetic energy equation and is applicable in transitional as well as fully-turbulent flow. This study is to provide a computation procedure which can be used to evaluate the factors affecting the onset of airfoil stall.
(*g*) Numerical solutions have been obtained for transitional bubbles on an NACA 66-018 airfoil at zero angle of incidence with chordal Reynolds numbers of 2.0 x 10^6 and 1.7 x 10^6, and these solutions have a qualitative behavior similar to that observed in numerous experiments; the solutions are also in reasonable quantitative agreement with available experimental data. Little difference is found between steady solutions of the boundary layer and Navier-Stokes equations for these flow conditions. Numerical studies based on mesh refinement suggest that the well-known singularity at separation, which is present in conventional solutions of the steady boundary layer equations when the free stream velocity is specified, is effectively removed when viscous-inviscid interaction is allowed to influence the imposed velocity distribution.
(*h*) **Numerical Prediction of Incompressible Separation Bubbles,** W. R. Briley, H. McDonald, *United Aircraft Res. Labs. Rept. N110887-3*, June 1974. To be published in *J. Fluid Mechanics*.

166-09068-050-00

LASER VELOCIMETER MEASUREMENTS IN RECIRCULATING FLOWS

(*c*) Dr. Kevin Owen.
(*d*) Experimental; applied research.
(*e*) Laser velocimetry techniques are being used to obtain measurements of the turbulence structure of recirculating flows. The study is to provide basic information required to evaluate and refine turbulence models being used in computational procedures for calculating flows with recirculation which utilize the time-averaged Navier-Stokes equations.
(*g*) Laser velocimeter measurements have been made in the initial mixing regions of free and confined coaxial jets with recirculation. Measurements of the axial and radial mean velocity profiles and the RMS and probability density distributions of the velocity fluctuations show that there are extensive regions of unsteady recirculating flow and these regions are substantially different for the two geometric configurations studied. The measured turbulent kinetic energy and shear stress distributions indicate that nonequilibrium effects are dominant in the initial mixing regions and that higher order turbulence models will probably be required to compute these flows.
(*h*) **Laser Velocimeter Measurements in Free and Confined Coaxial Jets With Recirculation,** F. K. Owen, *AIAA Paper No. 75-120*, Jan. 1975.

UTAH STATE UNIVERSITY, Utah Water Research Laboratory, College of Engineering, Logan, Utah 84322. Jay M. Bagley, Laboratory Director.

167-0147W-810-33

REGIONAL ANALYSIS OF RUNOFF CHARACTERISTICS OF SMALL URBAN WATERSHEDS

For summary, see Water Resources Research Catalog **8,** 6.1295.

167-0173W-800-15

INTERREGIONAL PLANNING OF WATER RESOURCES ALLOCATIONS BY SYSTEMS ANALYSIS APPROACH

For summary, see Water Resources Research Catalog **9,** 6.0976.

167-0174W-700-33

MEASUREMENT OF SOIL MOISTURE BY ATTENUATION OF RADIO FREQUENCY WAVES

For summary, see Water Resources Research Catalog **8,** 7.0239.

167-0175W-810-33

HYBRID COMPUTER SIMULATION OF THE HYDROLOGIC-SALINITY FLOW SYSTEM WITHIN THE BEAR RIVER BASIN

For summary, see Water Resources Research Catalog **8,** 6.1294.

167-0176W-870-33

EFFECTS OF WATER TEMPERATURE INCREASES ON TOXICITY OF WASTE DISCHARGES

For summary, see Water Resources Research Catalog **8,** 5.2432.

167-0180W-870-33

BIOLOGICAL EFFECTS ON INTERCHANGE OF METALS AND OF NUTRIENTS BETWEEN SEDIMENTS AND WATER

For summary, see Water Resources Research Catalog **8,** 5.2435.

167-0181W-800-33

A STUDY OF ALTERNATIVE METHODS TO MODERNIZE WATER INSTITUTIONS AND ELIMINATE PROBLEMS OF MULTIPLE JURISDICTION AND CONFLICTING OBJECTIVES

For summary, see Water Resources Research Catalog **8,** 6.1284.

167-0182W-800-33

EVALUATING WATER REUSE ALTERNATIVES IN WATER RESOURCE PLANNING

For summary, see Water Resources Research Catalog **9,** 6.0978.

167-0302W-800-31

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) (formerly 05750)

For summary, see Water Resources Research Catalog **9,** 3.0338.

167-0303W-840-07

MANAGEMENT OF SALT LOAD IN IRRIGATION AGRICULTURE (formerly 07736)

For summary, see Water Resources Research Catalog **9**, 5.1619.

167-0304W-370-47

URBAN STORM RUNOFF INLET HYDROGRAPH STUDY (formerly 08319)

For summary, see Water Resources Research Catalog **9**, 2.0935.

167-0305W-810-47

RUNOFF ESTIMATES FOR SMALL RURAL WATERSHEDS AND DEVELOPMENT OF SOUND DESIGN METHOD (formerly 08320)

For summary, see Water Resources Research Catalog **9**, 2.0937.

167-0306W-810-31

HYDROLOGIC SIMULATION FOR THE UPPER JORDAN DRAINAGE IN UTAH, USING HYBRID COMPUTER (formerly 08324)

For summary, see Water Resources Research Catalog **8**, 7.0242.

167-0307W-810-33

MODELING THE TOTAL HYDROLOGIC-SOCIOLOGIC FLOW SYSTEM OF URBAN AREAS – PHASE III (formerly 08325)

For summary, see Water Resources Research Catalog **9**, 6.0977.

167-0308W-870-33

INTERMITTENT SAND FILTRATION TO UPGRADE EXISTING WASTEWATER TREATMENT FACILITIES

For summary, see Water Resources Research Catalog **8**, 5.2433.

167-0309W-870-00

THE EFFECTS OF SELECTED BAFFLE CONFIGURATIONS ON THE OPERATION AND PERFORMANCE OF MODEL WASTEWATER STABILIZATION BASINS

For summary, see Water Resources Research Catalog **8**, 5.2434.

167-0310W-630-75

HYDRAULIC MODEL OF THE BOOSTER PUMP MANIFOLD FOR THE YORKTOWN POWER STATION

For summary, see Water Resources Research Catalog **8**, 8.0439.

167-0311W-820-33

MEASUREMENT OF SOIL MOISTURE BY USE OF THE LATENT HEAT OF VAPORIZATION

For summary, see Water Resources Research Catalog **9**, 2.0934.

167-0312W-200-00

RIVER AND HOMOGENEOUS ESTUARY UNSTEADY FLOW COMPUTATION

For summary, see Water Resources Research Catalog **9**, 2.0936.

167-0313W-800-07

WEATHER MODIFICATION IN UTAH

For summary, see Water Resources Research Catalog **9**, 2.0942.

167-0314W-820-05

DETERMINATION OF HYDRAULIC PROPERTIES OF UNSATURATED SOILS IN SITU THROUGH USE OF FIELD DATA AND NUMERICAL MODEL

For summary, see Water Resources Research Catalog **9**, 2.0943.

167-0315W-860-33

DEVELOPMENT OF A MODEL FOR EXAMINING ALTERNATIVE MANAGEMENT SCHEME ON GREAT SALT LAKE

For summary, see Water Resources Research Catalog **9**, 2.0946.

167-0316W-800-33

A TECHNIQUE FOR PREDICTING AQUATIC ECOSYSTEM RESPONSES TO WEATHER MODIFICATION

For summary, see Water Resources Research Catalog **9**, 2.0947.

167-0317W-860-60

WATER REUSE AND SALVAGE POTENTIALS IN UTAH

For summary, see Water Resources Research Catalog **9**, 3.0339.

167-0318W-810-60

QUALITY MANAGEMENT ON MOUNTAIN WATERSHEDS

For summary, see Water Resources Research Catalog **9**, 4.0203.

167-0319W-870-36

IMPLEMENTATION OF ALTERNATIVE ENVIRONMENTAL PHOSPHATE MANAGEMENT STRATEGIES

For summary, see Water Resources Research Catalog **9**, 5.1609.

167-0320W-870-36

ENVIRONMENTAL CARRYING CAPACITY AS A CONCEPT IN COMPREHENSIVE REGIONAL PLANNING – A FEASIBILITY STUDY

For summary, see Water Resources Research Catalog **9**, 5.1610.

167-0321W-870-33

PROCESS STUDIES AND MODELING OF SELF-CLEANING CAPACITY OF MOUNTAIN CREEKS FOR RECREATION PLANNING AND MANAGEMENT

For summary, see Water Resources Research Catalog **9**, 5.1611.

167-0323W-440-33

EFFECTS OF ARTIFICIAL DESTRATIFICATION ON MICROBIAL ACTIVITY IN HYRUM RESERVOIR

For summary, see Water Resources Research Catalog **9**, 5.1617.

167-0324W-810-65

STUDIES IN CONNECTION WITH HYDROLOGIC AND RELATED PHYSICAL PROCESSES IN THE OLYMPUS COVE AREA OF SALT LAKE COUNTY

For summary, see Water Resources Research Catalog **9**, 6.0982.

167-07730-810-05

WATERSHED INFILTRATION AND THE RESULTING FLOW SYSTEM

(*b*) Agricultural Research Service–Cooperative Agreement.
(*c*) Roland W. Jeppson, Professor.
(*d*) Basic-applied research.
(*e*) Infiltration characteristics of watershed soils are being studied by formulating initial value and boundary value problems with partial differential equations which result by considering fundamental soil properties and their influence on the unsaturated-saturated soil water flow system.
(*h*) **Relationships of Infiltration Characteristics to Parameters Describing the Hydraulic Properties of Soils,** *PRWG-59c-7*, Utah Water Res. Lab., June 1972.
Limitations of Some Finite Difference Methods in Solving the Strongly Nonlinear Equation of Unsaturated Flow in Soils, *PRWG-59c-8*, Utah Water Res. Lab., Sept. 1972.
Axisymmetric Infiltration in Soils, Part I, Numerical Techniques for Solution, *J. Hydrol.* **23**, pp. 111-130, 1974.
Part II, Summary of Infiltration Characteristics Related to Problem Specifications, *J. Hydrol.* **23**, pp. 191-202.
Use of Axisymmetric Infiltration Model and Field Data to Determine Hydraulic Properties of Soils, Utah Water Res. Lab., 1975.

167-07737-810-56

DEVELOPING A DETERMINISTIC, DISTRIBUTED NONLINEAR SURFACE-GROUNDWATER MODEL FOR THE ATLANTICO 3 PROJECT, COLOMBIA, SOUTH AMERICA

(*b*) U. S. Agency for International Development.
(*c*) Dr. J. Paul Riley, Assoc. Professor.
(*d*) Theoretical and experimental; applied research for M.S. theses and Ph.D. dissertations.
(*e*) Develop a simulation model of the joint hydrologic-economic system for the project area. The hydrologic model will include detailed definition of groundwater flow in both the unsaturated and saturated zones. The model will then be used to test various management alternatives under differing conditions of irrigation application rates and vegetative cover (both native and cultivated).
(*f*) Completed.
(*h*) **A Hybrid Computer Model of the Hydrologic System Within the Atlantico 3 Area of Colombia, South America,** J. P. Riley, E. K. Israelson, *Progress Report*, Utah Water Res. Laboratory, Utah State Univ., Logan, Utah.

167-07740-440-61

THE EFFECTS OF WIND ON CIRCULATION AND DISPERSION IN A SHALLOW DENSITY-STRATIFIED POND

(*b*) Center for Water Resources Research.
(*c*) Gary Z. Watters, Assoc. Dean, College of Engineering.
(*d*) Experimental; for Ph.D. dissertation, basic research.
(*e*) The effects of wind on the circulating patterns and the dispersive characteristics in density stratified shallow bodies of water are not well known. In this work a long shallow tank is constructed and filled with a density stratified fluid. Air is then drawn across the surface and the development of two-dimensional circulation patterns is observed. The results should indicate the importance of wind as a factor influencing dispersion in shallow ponds.
(*f*) Completed.
(*h*) **Two-Dimensional Wind-Generated Circulation and Dispersion in a Shallow Density-Stratified Body of Water,** *Ph.D. Dissertation*, in preparation, Utah State Univ., Logan, Utah.

167-08321-040-20

THREE-DIMENSIONAL CAVITY RESEARCH

(*b*) General Hydromechanics Research, Office of Naval Research.
(*c*) Roland W. Jeppson, Professor.
(*d*) Theoretical.
(*e*) Methods for solving general three-dimensional cavity fluid flows are being investigated. An inverse formulation has been developed which considers the magnitudes of the cartesian coordinates, the dependent variables in a space defined by the potential function, and two orthogonal stream surface functions. This formulation has the advantage that the region of most free surface and cavity flow problems is confined to a parallelepiped region in the inverse space. This approach could provide a practical means for obtaining numerical solutions to problems for which a comparable solution in the physical space would be extremely difficult.
(*f*) Completed.
(*h*) **Studies to Develop and Investigate an Inverse Formulation for Numerically Solving Three-Dimensional Free Surface Potential Fluid Flows,** *PRWG96-1*, Utah Water Res. Laboratory, Mar. 1971.
Solving Three-Dimensional Potential Flow Problems by Means of An Inverse Formulation and Finite Differences, *PRWG96-2*, Utah Water Res. Laboratory, Mar. 1973.

167-09069-800-33

DEVELOPMENT OF TECHNIQUES FOR ESTIMATING THE BENEFITS OF WATER RESOURCES DEVELOPMENT IN ACHIEVING NATIONAL AND REGIONAL SOCIAL GOALS (formerly 0179W).

(*b*) Office of Water Research and Technology, U. S. Dept. of the Interior.
(*c*) Dean F. Peterson, Vice President for Research, Utah State University, Logan, Utah 84321.
(*d*) Theoretical and experimental; basic and applied research.
(*e*) Project is being conducted by an interdisciplinary team representing seven western U. S. universities. Its purpose is to devise a planning methodology for comprehensive social evaluation of water resources development. The model identifies nine basic goals thought to be comprehensive. Specificity is added to these goals by a hierarchical dendritic array of successive definitional disaggregation leading eventually to measurable "social indicators" which are visualized as being changed by a water resources action. A test case in the lower Rio Grande led to development of a computerized model for projecting social indicators and an interactive planning information retrieval system.
(*f*) Completed. Final Report being prepared.
(*g*) A social-goal oriented comprehensive evaluative methodology for water resource planning has been devised and partially tested. Two computerized models have been developed: a social indicator projection system and an interactive planning inquiry system using the lower Rio Grande as a test case, five scenarios are projected reflecting three major developmental stances in the state, a surrogate for the economists "without" case, and a cotton-phase-out case. Connectives (linkages) were devised for 128 social indicators under three prime goals and one subgoal. Four five-year projections are made giving a 5 x 5 x 128 matrix of social indicator data. Connectives to goals and subgoals were devised using survey techniques. All information may be retrieved and displayed at different levels of disaggregation.
(*h*) The Technical Committee of the Water Resources Centers of the Thirteen Western States, 1971, **Water Resources Planning and Social Goals: Conceptualization Toward a New Methodology.** Prepared for the Office of Water Resources Research. *Utah Water Res. Lab. Publ. PRWG 94-1*. NTIS No. PB204228.
Social Goals Identification: A Survey Approach, D. D. Bracken, *M.A. Thesis*, Utah State University, 1971.

Technical Committee of the Water Resources Centers of the Thirteen Western States, 1973, **Summary Report of Phase II,** *PRWG-112-1*. Prepared for the Office of Water Resources Research. Project No. C-3377, Univ. of Calif., Riverside. Program in Environmental Economics.

The Concept and Function of Action Variables, J. T. Davenport, H. P. Caulifield, Jr., Program in Environmental Economics, *PRWG-112-2*, Univ. of Calif., Riverside, 1972.

A Model and Computer Program for Appraising Recreational Water Bodies, J. Thompson, R. Fletcher, Program in Environmental Economics, *PRWG-112-3*, Univ. of Calif., Riverside, 1972.

Test of a Planning Inquiry System: Water and Waste Management in Pima County and Suffolk County, T. G. Roefs, et al., *PRWG-112-4*, Univ. of Calif., Riverside, Dec. 1, 1972. Dept. of Environmental Economics, Riverside, Calif.

Economic Impact of a Large Water Resources Project: The Perris Dam, D. G. Hazzard, R. E. Lando, Program in Environmental Economics, *PRWG-112-5*, Univ. of Calif, Riverside, Calif., pp. 226-264, May 1, 1973.

Proceedings of the Graduate Student Symposium of the Technical Committee of the Water Resources Centers of the Thirteen Western States. A report prepared for the Inst. of Water Resources, Dept. of the Army, Corps of Engrs., Contract No. DACW 31-72-C-0060, Sept. 1972; *PRWG-120-1*. Edited and published at the Univ. of Calif., Riverside. Program in Environmental Economics.

Toward a Technique for Quantizing Aesthetic Quality of Water Resources, Feb. 1973, P. J. Brown, Editor. A report prepared for the Inst. of Water Resources, Dept. of the Army, Corps of Engrs., Contract No. DACW 31-72-C-0060. *PRWG-120-2*.

Special Panel. **Panel Review of the Taxonomic Structure of the Straw Man,** D. Harrah, T. Nagel, 1973. Report prepared under Project No. DACW 31-72-G-0060 for the Inst. for Water Resources, Dept. of the Army, Corps of Engrs., *PRWG-120-3*. Edited and published at the Univ. of California, Riverside. Program in Environmental Economics.

The Technical Committee of the Water Resources Research Institutes of the Thirteen Western States. Dec. 31, 1973. **Comments on a New Methodology for Water Resources Evaluation by a Review Panel.** Report of a demonstration prepared for the Inst. for Water Resources, Dept. of the Army Corps of Engrs., Contract No. DACW 31-72-C-0060.

167-09070-860-60

QUALITY-QUANTITY MANAGEMENT OF METROPOLITAN SUPPLY AND WASTEWATER SYSTEMS

(*b*) State of Utah Bureau of Environmental Health.
(*c*) Dr. William J. Grenney, Asst. Professor, Civil and Environmental Engineering.
(*d*) Theoretical; applied research; development; Ph.D. dissertation.
(*e*) Develop mathematical models (simulation and optimization) to assist water resource managers in reducing large amounts of data into useful representations for the decision making process. The research emphasis is involved with the new techniques; however, some preliminary applications are made to Salt Lake County, Utah. The study includes the development of an economic optimization model to be used as a management tool by regional and local planners for sequential expansion, upgrading and regionalization of wastewater treatment plants at a minimum total annual cost. The project also includes the development and application of a dynamic water quality model to the lower portions of the Jordan River in Utah.
(*h*) **Development of a Dynamic Program Model for the Regionalization and Staging of Wastewater Treatment Plants,** S. L. Klemetson, *Ph.D. Dissertation*, Civil Engrg. Dept., Utah State University, 185 pages, 1975.

167-09071-300-44

DEVELOPMENT OF A STREAMFLOW TEMPERATURE MODEL

(*b*) National Oceanic and Atmospheric Administration.
(*c*) Dr. William J. Grenney, Asst. Professor, Civil and Environmental Engineering.
(*d*) Experimental and theoretical; applied research; development; Master's thesis.
(*e*) Development of a mathematical model for predicting water temperatures under conditions of unsteady streamflow. The temperature model will be coupled to existing hydraulic model for unsteady flow. The model will be verified for a small mountain creek and a large river. Deterministic as well as stochastic techniques are being collected from a small mountain stream with special emphasis on diurnal variations and seasonal trends in heat transfer between the water and the stream bed.

167-09072-860-60

APPLICATION OF WATER RESOURCE MODELS TO THE WEBER RIVER

(*b*) State of Utah Bureau of Environmental Health.
(*c*) Dr. William J. Grenny, Asst. Professor, Civil and Environmental Engineering.
(*d*) Investigation and mathematical model application; applied research.
(*e*) Modify and apply a water quality model to the Weber River basin in Utah. A mathematical model (QUAL-II) was supplied by the United States Environmental Protection Agency and was modified during this project to streamline the input operations, increase the model's flexibility for analyzing various management alternatives, and expanded to include 10 water quality constituents. Field surveys were conducted to obtain data on the hydraulic properties of the stream channels in the system and also to locate and identify significant point loads, point diversions, and diffuse sources which might impact on stream water quality. The model was calibrated to water quality data obtained at over 80 sampling sites in the basin. The following water quality constitutents were modeled: biochemical oxygen demand, dissolved oxygen, ammonia, nitrate, orthophosphate, and coliform bacteria. The calibrated model was made available for use in wasteload allocation studies.
(*f*) Completed.
(*g*) During the study the model became unstable at points of large flow diversions from the stream channel. This problem was eliminated by modifying the solution algorithm. The model was found to represent the river basin reasonably well and was used as part of the wasteload allocation studies.
(*h*) **Development and Preliminary Application of Mathematical Models to the Weber Basin,** W. J. Grenney, D. S. Bowles, M. D. Chambers, J. P. Riley, Utah Water Res. Laboratory, Logan, Utah 84322 (in publication).
A River Simulation Model for Predicting Water Quality and Its Application to Utah River Basins, W. J. Grenny, D. S. Bowles, J. P. Riley. Submitted for publication.
Estimating Flow Conditions for River Models, W. J. Grenney, D. S. Bowles. Submitted for publication.

167-09073-300-06

THE RELATIONSHIP BETWEEN CHANNEL FORMING FLOWS AND THE CROSS-SECTION SHAPE, SLOPE AND BED MATERIAL IN LARGE BED ELEMENT STREAMS

(*b*) U. S. Forest Service.
(*c*) G. Z. Watters, Assoc. Dean, College of Engineering.
(*d*) Theoretical with field investigation; basic and applied research; Ph.D. dissertation.
(*e*) During highway construction or other engineering works, shortening, steepening or realigning of steep, rough channels may cause undesirable erosion. Relations are sought

between stream discharges, drainage areas, bed material size, channel slope and cross-section, as well as flow frequency to help design realigned channels effectively.
(*f*) Completed.
(*g*) See publications for results.
(*h*) **The Relationship Between Channel Forming Flows and The Cross-Section Shape, Slope and Bed Material in Large Bed Element Streams,** J. K. Virmani, *Ph.D. Dissertation*, 258 pages, 1973.
Discharge, Slope, Bed-Element Relations in Streams, J. K. Virmani, D. F. Peterson, G. Z. Watters, *Hydraul. Engrg. and the Environment, Proc. 1973 ASCE Hydr. Div. Conf.*, Bozeman, Mont., 12 pages, Aug. 1973.

167-09074-870-00

A MATHEMATICAL MODEL OF MIXING AND DISPERSION IN WASTE STABILIZATION PONDS USING THE FINITE ELEMENT METHOD

(*c*) G. Z. Watters, Assoc. Dean, College of Engineering.
(*d*) Theoretical investigation using previously collected data for model verification; basic research; Ph.D. dissertation.
(*e*) Previous research has shown that the degree of mixing in ponds drastically affects the treatment efficiency of the wastes. If mathematical modeling can be used to simulate the mixing and dispersion, treatment efficiency can be substantially improved without undertaking costly physical model studies. Navier-Stokes equations and the convection-diffusion equations will be solved using the finite element method. Experimental data taken from previous work will be used to check the validity and accuracy of the simulation.

167-09075-300-31

SIMULATION OF STEADY AND UNSTEADY FLOWS IN CHANNELS AND RIVERS

(*b*) U. S. Bureau of Reclamation.
(*c*) Roland W. Jeppson, Professor.
(*d*) Applied research.
(*e*) The unsteady Saint-Venant equations are solved by an implicit finite difference scheme to handle general channel and river flows. The initial conditions are provided by solving the steady varied flow equation under specified boundary conditions. Eight separate boundary conditions can be specified for the unsteady problem. Solutions give the spatial and time dependency of flow rate, depth, velocity, and include lateral flows. The channel geometry may be completely general.
(*f*) Completed.
(*h*) **Simulation of Steady and Unsteady Flows in Channels and Rivers,** *PRYNE-074-0-1*, Utah Water Res. Laboratory, Apr. 1974.

167-09076-860-33

FEASIBILITY OF STATE WATER-USE FEES FOR FINANCING WATER DEVELOPMENT AND COST SHARING

(*b*) Office of Water Research and Technology.
(*c*) Dr. Daniel H. Hoggan.
(*d*) Theoretical and field investigation, applied research.
(*e*) As a result of decreasing appropriations of federal funds for water projects in recent years, state and local governments are feeling the pressure to finance a larger share of the costs. One innovative approach to obtaining state funds for water development which appears to have promise is the application of state water-use fees to many or all of the major uses of water. This research project will analyze various use-fee arrangements to determine fund generating potential and feasibility.

167-09077-800-33

A REGIONAL APPROACH TO MULTI-OBJECTIVE PLANNING FOR WATER RELATED RESOURCES

(*b*) OWRT (joint project with University of Nevada).
(*c*) Dr. Daniel H. Hoggan.
(*d*) Theoretical and field investigation, applied research.
(*e*) Development of multiple-objective planning methodology using Virgin River Basin in Utah as a test basin.

167-09078-890-33

OPTIMIZING CROP PRODUCTION THROUGH CONTROL OF WATER AND SALINITY LEVELS IN THE SOIL

(*b*) U. S. Dept. of the Interior, Office of Water Resources and Technology.
(*c*) Dr. J. Paul Riley, Professor (project coordinator).
(*d*) Theoretical and experimental; applied research for M.S. and Ph.D. theses.
(*e*) Field studies are being conducted to examine the response of crops (in terms of dry matter and grain yield) to root stresses applied at different stages of crop growth. Root stresses are induced through both salinity concentrations in the soil moisture solutions and by soil moisture deficiencies. A model will be developed for general application of the results.

167-09079-810-75

HYDROLOGIC MODEL OF THE SAN JUAN RIVER BASIN

(*b*) Clyde-Criddle-Woodward, Inc.
(*c*) Dr. J. Paul Riley, Professor.
(*d*) Applied research for a consulting engineering firm.
(*e*) Develop a hydrologic model of the San Juan River basin (a tributary of the Colorado River). The model is being applied to study the impacts on river flows of various management alternatives involving Indian lands.
(*f*) Completed.
(*g*) The material was transmitted to the consulting firm for inclusion in its report. This report has not yet been released.

167-09080-810-06

COMPUTER SIMULATION MODELS TO DESCRIBE STREAMFLOW FROM FOREST WATERSHEDS

(*b*) USDA, Forest Service.
(*c*) Dr. J. Paul Riley, Professor.
(*d*) Theoretical and experimental; applied research for M.S. thesis.
(*e*) Derive, test, and apply fundamental hydrologic relationships to three small watersheds of the Entiat National Forest near Wenatchee, Washington. The digital computer is being used to compare runoff characteristics under pre-fire and post-fire conditions on the watersheds.
(*f*) Completed.
(*g*) An application of the Utah State University watershed simulation model to the Entiat Experimental Watershed, Washington State.

167-09081-370-88

EROSION CONTROL DURING HIGHWAY CONSTRUCTION

(*b*) Transportation Research Board.
(*c*) Calvin G. Clyde, Assoc. Director.
(*d*) Field investigation, applied research.
(*e*) Uncontrolled water and wind erosion resulting from construction activities cause significant damage to the environment. Objectives of this project are to assess the effectiveness of methods that have been or are being used to control erosion from highway construction; develop a manual of recommended techniques and design criteria for the control of erosion, using hydrologic, hydraulic, agronomic, pedologic and economic principles; and to identify research needs in the subject area.

167-09082-860-33

AN EMPIRICAL ANALYSIS OF PREDICTORS OF INCOME DISTRIBUTION IMPACTS OF WATER QUALITY CONTROLS

(*b*) Office of Water Research and Technology, Dept. of the Interior.
(*c*) John E. Keith, Research Economist, UMC 82.
(*d*) Theoretical and field investigation.

(*e*) Established to test the efficiency of three suggested estimators and predictors of income distribution, the Gamma distribution function, the Beta distribution function, and an econometric model. Research is focused on water quality controls and their impact on income distribution. Data is gathered from comparable counties, functional economic areas, or other appropriate regions, in order to compare regions with no water quality controls (or lacking a specific control policy) with regions in which various levels of a given control are enforced. The three models or tools will be used to predict changes in the Lorenz curve and/or Gini coefficients, and those predictions will be compared to determine the most efficient predictors. These predictors will then be used to predict impacts of policy alternatives for specified areas.

167-09083-800-60

WATER LAND USE MANAGEMENT MODEL FOR THE SEVIER RIVER BASIN

(*b*) State of Utah.
(*c*) Eugene K. Israelsen.
(*d*) Theoretical and experimental; applied research for M.S. thesis.
(*e*) A general hydrologic and salinity model is being applied to the Sevier River basin in Central Utah. The primary purpose of the study is to develop predictive capability for the Office of the State Engineer for evaluating the effects of water management practices on downstream water quantity and quality levels within the Sevier River basin.

167-09084-210-70

HEAD LOSSES DUE TO RING-TITLE FILAMENT WOUND ELBOWS AND TEES AND FRICTIONAL LOSSES IN PIPES OF POLYVINYLCHLORIDE

(*b*) Johns-Manville.
(*c*) Roland W. Jeppson, Professor.
(*d*) Experimental.
(*e*) Laboratory test determined the head losses due to fittings used in conjunction with PVC pipe. Loss coefficients for tees were determined for the various possible configurations of flow. The measurements were also used to determine the hydraulic characteristics of PVC pipe and its wall roughness.
(*f*) Completed.
(*h*) **Head Losses Due to Ring-Title Filament Wound Elbows and Tees and Frictional Losses in Pipes of Polyvinylchloride,** *PRWG-132-1*, Utah Water Res. Lab., Feb. 1973.

VANDERBILT UNIVERSITY, Environmental and Water Resources Engineering, Nashville, Tenn. 37235. Dr. Barry A. Benedict.

168-08330-870-00

STRATEGIES FOR REDUCING COOLING POND SIZE

(*d*) Theoretical; applied research; Ph.D. thesis.
(*e*) A stochastic model of equilibrium temperature and heat exchange coefficient has been developed. Once developed, this model was used as input into a deterministic cooling pond model. Use of this double model approach will allow cooling ponds to be analyzed under transient conditions.
(*f*) Completed.
(*g*) A useful stochastic model was found for the equilibrium temperature in the cooling coefficient. This technique was applied to meteorological data from five widely separated sites around the United States. It was shown to have utility as a tool for evaluating the failure potential of a cooling pond as measured in terms of the numbers of days each year when certain temperature criteria are exceeded. A risk analysis, with subsequent increases in efficiency of designs, is now possible.

VIRGINIA INSTITUTE OF MARINE SCIENCE, COMMONWEALTH OF VIRGINIA, Department of Physical Oceanography and Hydraulics, Gloucester Point, Va. 23062. Dr. C. S. Fang, Department Head.

169-08332-870-52

FATE OF WASTE HEAT DISCHARGED INTO THE JAMES RIVER ESTUARY BY THE SURRY NUCLEAR POWER STATION AT HOG POINT, SURRY COUNTY, VIRGINIA

(*b*) Energy Research and Development Administration.
(*c*) C. S. Fang, Senior Marine Scientist; G. C. Parker, graduate student.
(*d*) Field investigation; applied research.
(*e*) Temperature profiles in the vicinity of the mixing zone of the heated water discharge plume are being determined. Deduced thermal patterns will be compared with those obtained from previous model studies under similar wind and flow conditions to evaluate the relevance of model studies for these purposes. The importance of winds on the movement of the thermal effluent is under particular consideration.
(*g*) Data collected to date does not indicate that there are any extreme temperatures outside the near field region of the outfall that could cause biological damage. Continued monitoring of the area is necessary to identify yearly variation of parameters and to monitor under higher plant output conditions. Data taken during 1973 indicate that the thermal plume is not as extensive as predicted by the James River Hydraulic Model. This model is best suited for far field analysis of the thermal plume.
(*h*) **The Design of the Monitoring System for the Thermal Effects Study of the Surry Nuclear Power Plant on the James River,** R. L. Bolus, S. N. Chia, C. S. Fang, *VIMS SRAMSOE* **16**, Oct. 1971.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part II. Results of Monitoring Physical Parameters of the Environment Prior to Plant Operation, S. N. Chia, C. S. Fang, R. L. Bolus, W. J. Hargis, Jr., *VIMS SRAMSOE* **21**, Feb. 1972.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part III. Results of Monitoring Physical Parameters of the Environment Prior to Plant Operation, E. A. Shearls, S. N. Chia, W. J. Hargis, Jr., C. S. Fang, R. N. Lobecker, *VIMS SRAMSOE* **33**, Feb. 1973.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part IV. Results of Monitoring Physical Parameters During the First Year of Plant Operation, *VIMS SRAMSOE* **51**, Feb. 1974.
An Estuarine Thermal Monitoring Program, C. S. Fang, G. C. Parker, E. A. Shearls, W. J. Hargis, *Thermal Pollution Analysis Conf.*, VPI and SU, Blacksburg, Va., May 1974.
Hydrothermal Monitoring: Surry Nuclear Power Plant, C. S. Fang, G. Parker, W. Harrison, *14th Intl. Conf. Coastal Engrg.*, Copenhagen, Denmark, June 1974.
The Design of a Thermal Monitoring System, R. L. Bolus, C. S. Fang, S. N. Chia, *Marine Tech. Soc. J.* **7**, 7, 1973.

169-08340-050-54

TWO-DIMENSIONAL JET DISCHARGING INTO AMBIENT FLUID OF CROSS STREAM

(*b*) National Science Foundation (RANN Program).
(*c*) A. Y. Kuo, Associate Marine Scientist.
(*d*) Theoretical, applied research for Master's thesis. Project represents a subproject of the Waste Water Treatment program of the Chesapeake Research Consortium, Inc.
(*e*) Numerical computation was performed for the flow field induced by a two-dimensional jet discharging into ambient fluid of uniform velocity. The boundary conditions simulate the flow of water from the Chesapeake Bay into the Atlantic Ocean. Coriolis parameter was included in the computation.
(*f*) Completed.

(*g*) The speculated gyre off Virginia Beach is not a stable feature of the circulation averaged over tidal cycle. It is a transient feature, if the gyre does exist.
(*h*) **A Two-Dimensional Jet Flowing Into a Semi-Infinite Flow Field With An Ambient Velocity**, M. L. Crane, *Master's Thesis*.

169-08343-400-10

HYDROGRAPHIC STUDIES OF CHESAPEAKE BAY – COLLECTION OF HYDROGRAPHIC DATA ON CHESAPEAKE BAY AND TRIBUTARIES

(*b*) U. S. Army Corps of Engineers.
(*c*) Dr. C. S. Fang, E. P. Ruzecki, W. Athearn.
(*d*) Field investigation; basic research.
(*e*) Hydrographic data consisting of measurements of tidal elevation, current velocity, temperature and salinity are being collected from the Virginia waters of Chesapeake Bay and its major tributaries within Virginia, the James, York and Rappahannock Rivers and Pocomoke Sound. The field work is directed toward the verification of the Chesapeake Bay Hydraulic Model being built under the supervision of the Corps of Engineers, Baltimore District, in cooperation with Chesapeake Bay Institute and Chesapeake Biological Laboratory, who are working primarily within the Maryland section of the Bay system.
(*f*) Completed.
(*g*) Methods, position and times of data were collected and data in tabular form were furnished to Corps of Engineers.
(*h*) **Hydrography and Hydrodynamics of Virginia Estuaries. Part V. A Report on the Prototype Data Collected in the Rappahannock River and Mobjack Bay for the Chesapeake Bay Model Study**, *VIMS Spec. Rept. 68*, in *Applied Marine Science and Ocean Engineering*.

169-09144-220-22

SUSPENDED SEDIMENT STUDIES AT NORFOLK NAVAL BASE PIER 12

(*b*) Department of Navy; Virginia Institute of Marine Science.
(*c*) E. P. Ruzecki, Associate Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) Determine quantity for size distribution of suspended sediment in region of pier 12 Norfolk Navy Base under varying conditions of river flow, tides, and wind.
(*f*) Completed.
(*g*) Data report furnished to Engineering Office, Norfolk Naval Base.
(*h*) **Suspended Sediments Near Pier 12 Norfolk Naval Base on 26 June and 15 September, 1973**, E. P. Ruzecki, R. Ayers, *VIMS Data Rept. 11*.

169-09145-300-65

LONG CREEK/CANAL CHANNEL EROSION STUDY

(*b*) Virginia Institute of Marine Science; City of Virginia Beach.
(*c*) B. J. Neilson, Associate Marine Scientist.
(*d*) Field investigation, applied research, design.
(*e*) Determine causes of bank and channel-bottom erosion in Long Creek canal connecting Lynnhaven Bay with Broad Bay. Conceptual model for tidal hydraulics developed to evaluate various solutions.
(*f*) Completed.
(*g*) Final result was that dredging of Long Creek was rejected and the suggested remedy was to remove the constriction which occurred near the bridge. The study showed that removal of this constriction would not change the flows overall but would reduce local velocities.
(*h*) **Hydraulic Study of Long Creek and Lynnhaven Waters**, B. Neilson, Feb. 15, 1974.

169-09146-400-00

JAMES RIVER MOUTH CIRCULATION STUDY

(*c*) C. S. Welch, Associate Marine Scientist.
(*d*) Development, field investigation.
(*e*) To study the circulation in the close proximity of Newport News point in consultation with State Highway Department. Model test and direct current study were carried out to predict the effects of erosion due to changed current patterns.
(*f*) Completed.
(*g*) Minimum impact on existing flow field could be expected if tunnel island is built on and oriented parallel to Newport News Bar. Circulation near Newport News Point characterized by a nearly cut-off eddy.
(*h*) **Physical and Geological Studies of the Proposed Bridge-Tunnel Crossing of Hampton Roads Near Craney Island**, C. S. Fang, B. J. Neilson, A. Y. Kuo, R. J. Byrne, C. S. Welch.

169-09147-410-50

NEARSHORE CIRCULATION PROJECT

(*b*) National Aeronautics and Space Administration, Wallops Island Station; Virginia Institute of Marine Science.
(*c*) J. M. Zeigler, Asst. Director; C. S. Fang, Senior Marine Scientist; R. J. Byrne, Senior Marine Scientist; C. S. Welch, Assoc. Marine Scientist.
(*d*) Development and application.
(*e*) Field exercises were run at Wachapreague Inlet to determine flow pattern and local continental shelf region with emphasis on water exchange between shelf and marsh during tidal cycle. A surface radar drogued buoy system was used to provide additional data. Development of a transponding Omega navigation buoy continues.
(*g*) Offshore flow extremely wind dependent; direct tidal influence of inlet decaying rapidly away from mouth; most water leaving Wachapreague Inlet does not re-enter it directly.
(*h*) **Annual Report for Year 1 for Application of Remote Sensing to Study Nearshore Circulation**, C. S. Welch, L. Haas.
Annual Report for Year 2 for Application of Remote Sensing to Study Nearshore Circulation, J. Zeigler, L. Haas, R. Loebecker, D. Stauble, C. Welch, C. S. Fang.

169-09148-300-54

FIELD STUDIES OF WASTE AND DISPERSION CHARACTERISTICS OF THE ELIZABETH RIVER

(*b*) National Science Foundation (RANN Program); Virginia Institute of Marine Science.
(*c*) C. S. Fang, Senior Marine Scientist; B. J. Neilson, Assoc. Marine Scientist; A. Y. Kuo, Assoc. Marine Scientist.
(*d*) Field investigation, applied research, design, operation, development.
(*e*) Hydrographic surveys were conducted in the Elizabeth River to determine nature of water quality and circulation patterns. Dye releases from sewage treatment plants were conducted to follow dispersion of the effluent. Data was used to construct a mathematical model used to examine three possible courses of action for sewage treatment plant-river system: 1) upgrade level of treatment at present plants; 2) relocate and redesign present outfalls; and 3) remove the outfalls from the river (ocean outfall). In addition, the data gathered by comparing the Elizabeth River with other major sewage treatment plant outfall plants will be used to develop a generalized model of the dispersion characteristics of outfall locations to be used in comparing outfalls of the James River.
(*f*) Completed.
(*g*) The Elizabeth River flushes slowly. A mathematical model will be available to test the future of project's impacts.
(*h*) **Field Studies of Waste and Dispersion Characteristics of the Elizabeth River**, *Annual Report*.

169-09149-400-60

A MATHEMATICAL MODEL OF TIDAL HYDRAULICS IN ESTUARINE RIVER

(*b*) State Water Control Board; Virginia Institute of Marine Science.
(*c*) A. Y. Kuo, Assoc. Marine Scientist.
(*d*) Master's thesis.

(e) Having derived a one-dimensional continuity equation, momentum equation, and mass balance equation of salt by averaging the general three-dimensional equations over a cross section of the estuarine river, equations were applied to the James River estuary.
(f) Completed.
(g) A one-dimensional model can give a reasonable representation of the estuarine river in normal discharge condition but only qualitative results during the hurricane period unless the barometric effect is included in the model.
(h) **One-Dimensional Mathematical Model of Tidal Hydraulics and Salt Intrusion in Estuarine Rivers,** F.-D. Lin, *Master's Thesis.*

169-09150-410-00

DRIFT BOTTLE/SEABED DRIFTER ANALYSIS

(c) C. S. Welch, Assoc. Marine Scientist; J. J. Norcross, Senior Marine Scientist.
(d) Applied data analysis.
(e) Project consisted of analysis of drift bottle/seabed drifter data from project MACONS with respect to use in coastal management and consideration of the relation to siting of offshore ports and sewage outfalls.
(f) Completed.
(g) Certain small segments of beach are particularly susceptible to landings of bottom drifters. The Dam Neck/Virginia Beach Sewage Outfall is located on a site which will produce beached effluent more often than any other beach location in Virginia.
(h) **The Use of Drift Bottle/Seabed Drifter Data to Optimize Decisions on Coastal Zone Use,** C. S. Welch, J. J. Norcross, *VIMS Spec. Rept. 44*, in *Applied Marine Science and Ocean Engineering.*

169-09151-450-00

A TWO-DIMENSIONAL MATHEMATICAL MODEL FOR THE COASTAL SEA OFF THE CHESAPEAKE BAY MOUTH

(c) A. Y. Kuo, Assoc. Marine Scientist.
(d) Ph.D. dissertation.
(e) Two-dimensional continuity equation, momentum equations, and mass balance equation of salt have been derived by integrating the general three-dimensional equations over depth. The equations will be applied to an area of coastal sea off the Chesapeake Bay mouth in order to predict the coastal circulation pattern under varying conditions of tide, winds, and freshwater discharge from the Bay.
(h) *Ph.D. Dissertation*, E. M. Stanley.

169-09152-450-50

WIND GENERATED INERTIAL CURRENTS

(b) National Aeronautics and Space Administration, Wallops Island Station; Virginia Institute of Marine Science.
(c) C. S. Welch, Assoc. Marine Scientist; W. Saunders, graduate student.
(d) Thesis research.
(e) A study of the effects of wind generation on inertial currents in the Atlantic Ocean. Data from current meters and anemometers are being used in addition to a mathematical model used to predict inertial currents. This model includes the effects of wind field over the array.

169-09153-450-50

SURFACE TIDAL CIRCULATION OF MOBJACK BAY

(b) National Aeronautics and Space Administration, Wallops Island Station; Virginia Institute of Marine Science.
(c) C. S. Welch, Assoc. Marine Scientist.
(d) Thesis research.
(e) Comparison of the total differentiation of surface (two feet) current velocity with respect to time can be made using direct and indirect methods. Semi-diurnal and diurnal constituents for deriving the tidal ellipses of seven current meter stations were found by analyzing the power spectra of current velocity measurements. A Spar Buoy has been designed and the triangulation techniques employed for collecting Lagrangian data.

169-09154-450-50

VIMS-NASA-LRC COOPERATIVE SHELF CIRCULATION STUDY

(b) Virginia Institute of Marine Science; National Aeronautics and Space Administration, Langley Research Center.
(c) J. M. Zeigler, Asst. Director; P. V. Hyer, Assoc. Marine Scientist.
(d) Experimental, design.
(e) To study turbulent water-mass exchanges over the continental shelf and slope. NOAA-II photography has been used for rapid detection of warm-water intrusions and air deployment of free-drifting telemetering buoys for study of evolution of these features.
(f) Completed.
(g) Specific experiments to study particular phenomena of continental shelf circulation were found to be more valuable than routine surveys. More data is necessary to provide adequate information on exchange processes. There is a role for remote sensing to play in study of shelf zone.
(h) **New Approaches to the Study of the Circulation on the Continental Shelf,** P. V. Hyer, contract report to NASA-LRC, Sept. 1973.

169-09155-400-54

OPERATION AGNES

(b) National Science Foundation; Virginia Institute of Marine Science.
(c) A. Y. Kuo, Assoc. Marine Scientist; C. S. Fang, Senior Marine Scientist; E. P. Ruzecki, Assoc. Marine Scientist.
(d) Applied research.
(e) To monitor effects of the flood water on the circulation of the Bay System and on the transport of material substances including nutrients, suspended sediments, pesticides and metals. The project emphasized the path of the Susquehanna River water as it passes down the Bay, out of the mouth, and onto the shelf.
(f) Completed.
(g) Transient response of the Bay salinity structure to flood water may be divided into four stages: 1) flushing of surface layer; 2) downstream displacement of lower layer; 3) overshoot of lower layer recovery through gravitational circulation; and 4) recovery of surface layer through mixing. After leaving the Bay, the flood water moves southward with speed on the order of 80 cm/second.
(h) **The Effects of Agnes Flood On the Salinity Structure of the Lower Chesapeake Bay and Contiguous Waters,** A. Y. Kuo, *Effects of Tropical Storm Agnes On the Chesapeake Bay Estuarine System, Chesapeake Research Consortium, Inc., No. 34*, June 1974.

169-09156-300-13

RAPPAHANNOCK RIVER MONITORING STATION

(b) U. S. Army Corps of Engineers, Norfolk District; Virginia Institute of Marine Science.
(c) C. S. Fang, Senior Marine Scientist; G. L. Parker, graduate assistant.
(d) Field investigation.
(e) Two water temperature and salinity monitoring stations have been installed on the Rappahannock River, one at Smokey Point and one at Grey's Point. At each location, there are two sets of temperature-salinity sensors.
(f) Completed October 1974.
(g) Final report in preparation.
(h) **Salinity and Temperature Monitoring Stations at Lower Rappahannock River,** C. S. Fang, G. L. Parker, W. J. Hargis, Jr., *Special Report 32* in *Applied Marine Science and Ocean Engineering.*

169-09157-300-73

PAMUNKEY RIVER MONITORING STATION

(*b*) Virginia Electric and Power Company; Virginia Institute of Marine Science.
(*c*) C. S. Fang, Senior Marine Scientist.
(*d*) Field investigation.
(*e*) Two stations in the York River system, one on the Ferry Pier at the Virginia Institute of Marine Science and the other at Olssons Landing on the Pamunkey River, are currently operating to monitor water temperature and salinity continuously.
(*f*) Suspended until notification
(*g*) One year of salinity and temperature data has been collected (1973).

169-09158-870-73

BATHYMETRIC STUDY OF LOWER YORK RIVER ADJACENT TO VEPCO YORKTOWN POWER STATION

(*b*) Virginia Electric and Power Company; Virginia Institute of Marine Science.
(*c*) John Jacobson, Asst. Marine Scientist.
(*d*) Field investigation, operation.
(*e*) This Vepco contract performs three comprehensive bathymetric surveys of the York River adjacent to construction of hot water discharge outfall of Yorktown Power Plant. Surveys were made prior to installation of discharge pipe and immediately following installation. The final survey is scheduled for December 1975.
(*f*) Two surveys have been done.
(*g*) Two survey reports have been sent to Vepco and the Army Corps of Engineers in Norfolk District.

169-09159-370-60

I-64 FIELD SURVEY FOR I-664 BRIDGE-TUNNEL DESIGN

(*b*) Virginia State Highway Department; Virginia Institute of Marine Science.
(*c*) C. S. Fang, Senior Marine Scientist; B. J. Neilson, Assoc. Marine Scientist; D. Haven, Senior Marine Scientist; D. Boesh, Assoc. Marine Scientist; J. D. Boon, Assoc. Marine Scientist.
(*d*) Field investigation, applied research, design.
(*e*) An intensive field study has been conducted to note and document any changes occurring to the natural environment during construction of the second tunnel for I-64 crossing (Hampton Roads Bridge Tunnel) in order to provide additional information for the design of I-664 crossing. Results of physical studies are being coordinated with geological, benthic, and shellfish studies.
(*f*) Completed.
(*g*) Precautions taken during construction were effective and environmental impact was slight.
(*h*) **Physical, Geological and Biological Effects of Hampton Roads Bridge Tunnel Construction.** Final report, in printing.

169-09160-870-65

ENVIRONMENTAL EFFECTS GENERATED BY SEWAGE IN HAMPTON ROADS

(*b*) Hampton Roads Sanitation District Commission for McGaughy, Marshall and McMillan-Hazen and Sawyer.
(*c*) B. Neilson, Assoc. Marine Scientist; C. S. Fang, Senior Marine Scientist; A. Y. Kuo, Assoc. Marine Scientist; J. Jacobson, Asst. Marine Scientist; M. Bender, Asst. Director; F. Perkins, Senior Marine Scientist; D. Haven, Senior Marine Scientist.
(*d*) Applied research, design, operation, development.
(*e*) Determine existing conditions and to make the necessary studies in order to assess likely environmental impacts from the proposed Pig Point STP (Sewage Treatment Plant). Several aspects were involved: 1) An analysis of the existing data on currents in Hampton Roads. The idea was to have a better understanding of the circulation, which will actually determine where the effluent goes. 2) Regular slack water monitoring of existing conditions during the summer of 1974. This included hydrographic parameters (T. Sal, DO, BOD), bacteriological (total and fecal coliforms – MPN's) and nutrients. 3) The field dye studies – an ebb and a flood dye study, each one including slack water monitoring of the dye plumes for several days after release. 4) A mathematical dispersion simulation model to take the field dye studies results and so analyze them that predictions could be made for the slack tide (both high and low) distributions of both conservative (dye, total nitrogen, total phosphorus) and nonconservative (coliforms, BOD, ammonia, etc.) substances. 5) A survey of shellfish.
(*f*) Completed.
(*g*) A better understanding of circulation in Hampton Roads, a documentation of the existing water quality conditions, a predictive math model which can show concentration distributions for effluent constituents – all of which are needed for the environmental impact assessment.
(*h*) Report will be submitted in five volumes: 1. **Summary of Findings and Conclusion/Survey of Existing Conditions**; 2. **Circulation in Hampton Roads;** 3. **1974 Water Quality Monitoring,** B. Neilson; 4. **Survey of Shellfish Grounds,** D. Haven Senior Marine Scientist; 5. **Predictive Model,** A. Y. Kuo, J. Jacobson.

169-09161-870-65

NORFOLK ARMY BASE SEWAGE EFFLUENT STUDY

(*b*) Hampton Roads Sanitation District Commission, through Hayes, Seay, Mattern, and Mattern.
(*c*) B. Neilson, Assoc. Marine Scientist.
(*d*) Field investigation, design, operation.
(*e*) The study is to look at the distribution of effluents from the Army Base and Lambert Point STP's on the Elizabeth River, specifically, should the outfall locations be moved in order to get better water quality in the Elizabeth River. The mathematical model developed for the RANN project will be used to test various locations. The model was reverified using the results of the Army Base dye study. Dye was injected into the plant's effluents and followed in the river.

169-09162-310-13

EFFECTS OF HURRICANE AGNES ON TIDAL HEIGHTS AND CURRENTS IN THE JAMES RIVER

(*b*) Army Corps of Engineers, Baltimore District; Virginia Institute of Marine Science.
(*c*) J. Jacobson, Asst. Marine Scientist; C. S. Fang, Senior Marine Scientist.
(*d*) Applied research.
(*e*) Available data was used to describe the propagation of flood wave down the James.
(*f*) Completed.
(*g*) Hurricane Agnes produced a record flood at Richmond upstream of the tidal portion of the James River. The effects of this flood are slight in the saline portion of the James. Tidal heights were only one foot above normal and surface currents did not flood for two tidal cycles due to the passage of the flood wave.
(*h*) **Effects of Hurricane Agnes on Tidal Heights and Currents in the James River,** J. Jacobson, C. S. Fang, *Chesapeake Research Consortium, Inc., No. 34*, June 1974.
Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System, presented at *Symp. on Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System.*

169-09163-860-88

INVENTORY AND PROJECTION OF WATER

(*b*) National Commission on Water Quality.
(*c*) C. S. Fang, Senior Marine Scientist; A. Y. Kuo, Assoc. Marine Scientist; A. Rosenbaum, Asst. Marine Scientist; M. Bender, Asst. Director; M. Roberts, Assoc. Marine Scientist; D. Bosch, Assoc. Marine Scientist.
(*d*) Applied research.
(*e*) Prepare descriptions of present Chesapeake Bay water quantity and quality, projections of future water quality and assessing the biological, ecological and environmental impacts.

(*h*) The Chesapeake Bay System: **Effluent and Ambient Water Quality Conditions,** an interim report.

169-09164-870-75

SMALL BOAT HARBOR SEWAGE TREATMENT PLANT OUTFALL SITE DESIGN STUDY

(*b*) Hayes, Seay, Mattern, and Mattern.
(*c*) C. S. Welch, Assoc. Marine Scientist; B. Neilson, Assoc. Marine Scientist.
(*d*) Design, river field investigation.
(*e*) Remote sensing techniques were used to evaluate the tidal circulation near several proposed sewage outfall sites.
(*f*) Completed.

169-09165-400-60

COOPERATING STATE AGENCIES (CSA) ESTUARINE WATER QUALITY MODELING PROGRAM

(*b*) Virginia State Water Control Board, Richmond, Virginia.
(*c*) C. S. Fang, Senior Marine Scientist; A. Y. Kuo, Assoc. Marine Scientist; P. V. Hyer, Assoc. Marine Scientist; A. Rosenbaum, Asst. Marine Scientist.
(*d*) Experimental, including field investigation and numerical modeling; applied research.
(*e*) A sequence of water quality models is being developed for Virginia estuaries for use by planning agencies as a management aid. The James, York, Rappahannock, and several smaller estuaries are included. The project commenced with one-dimensional salinity intrusion and dissolved oxygen models of the major estuaries but has expanded to encompass dynamic modeling, modeling of nitrogenous BOD and two-dimensional and two-layer modeling.
(*g*) Field studies indicate that low oxygen conditions occur on a localized and seasonal basis, indicating the need for modeling to assess the impact of development on critical conditions. Estuarine stratification and water quality are clearly influenced by the annual hydrologic cycle.
(*h*) **Hydrography and Hydrodynamics of Virginia Estuaries, Part IV. Mathmatical Model Studies of Water Quality in the James Estuary,** C. S. Fang, et al., *Spec. Rept. No. 41*, Va. Inst. of Marine Science, Sept. 1973.
Mathematical Modeling of Virginia Estuaries for Management, C. S. Fang, A. Y. Kuo, P. V. Hyer, presented Virginia Academy of Science, Norfolk, Va., May 1974.
A Long-Term Dispersion Model of Conservative Substance in the Estuarine Rivers, C. S. Fang, M. A. Orzech, A. Y. Kuo, *Special Science Rept. 28*, Va. Inst. of Marine Science, June 1973.

169-09166-400-13

HYDROGRAPHIC STUDIES OF CHESAPEAKE BAY - COLLECTION OF HYDROGRAPHIC DATA ON CHESAPEAKE BAY AND TRIBUTARIES

(*b*) U. S. Army Corps of Engineers.
(*c*) C. S. Fang, Senior Marine Scientist; E. P. Ruzeck, Assoc. Marine Scientist; J. Jacobson, Asst. Marine Scientist.
(*d*) Field investigation, basic research.
(*e*) Hydrographic data consisting of measurements of current velocity, temperature, and salinity were collected from the Virginia waters of Chesapeake Bay and its major tributaries within Virginia, the James, York, Back, Poquoson, Piankatank, and Great Wicomico rivers. Field work is directed toward the verification of the Chesapeake Bay Hydraulic Model being built under the supervision of the Corps of Engineers, Baltimore District, in cooperation with Chesapeake Bay Institute and Chesapeake Biological Laboratory.
(*f*) Field data collection has been completed and data have been reduced and tabulated; project completed.
(*g*) Data for temperature, salinity, and currents have been furnished to the Corps of Engineers.

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VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, Blacksburg, Va. 24061. Dr. R. D. Walker, Department Head.

171-08355-300-60

FLOW ROUTING IN THE JAMES RIVER WITH SPECIAL APPLICATION

(*b*) Division of Water Resources, Commonwealth of Virginia.
(*c*) D. N. Contractor, Asst. Professor.
(*d*) Theoretical, applied research, operation.
(*e*) Extension of the technique of numerical flow routing to conditions of very high flows, low flows and effect of a dam.
(*f*) Completed.
(*g*) Computer program successfully completed.

171-08356-220-00

DETERMINATION OF A UNIT SEDIMENTGRAPH

(*c*) D. N. Contractor, Asst. Professor.
(*d*) Experimental and field investigation; applied research, Doctoral thesis.
(*e*) An attempt to determine the sediment flow charcteristics of watersheds and those characteristics that vary with streamflow, rainfall and land use. The significant sediment flows occur during periods of high discharge. The anticipated results should permit assessment of suspended sediment transport.
(*f*) Completed.
(*g*) A method is presented that is analogous to Sherman's unit-hydrograph method. The ordinates of a sediment discharge graph are divided by the excess runoff that mobilized it, producing a unit sediment discharge graph. For many storm events, unit sediment discharge graphs are generated that vary considerably in peak value and shape. The ordinates of the latter graphs are then plotted logarithmically against their respective excess runoff, yielding data points that can be fitted by straight lines. Estimation of sediment discharge or of a sediment discharge graph for a given excess runoff can therefore be accomplished. Bixler Run Watershed, Pa., 15 sq. miles (39 sq. km) in area, was selected as a data source. Granulometric tests disclosed that the suspended sediment in Bixler Run is predominantly washload.
(*h*) **Estimation of Washload Produced on Certain Small Watershed,** O. Rendon-Herrero, *J. Hydraul. Div., ASCE* **100,** HY7, *Proc. Paper 10638*, pp. 835-848, July 1974.

171-09167-870-33

IDENTIFICATION OF FACTORS AFFECTING WATER QUALITY FROM STRIP-MINED SITES

(*b*) Office of Water Resources Research, Blacksburg, Va.
(*c*) D. N. Contractor, Asst. Professor.
(*d*) Theoretical study; applied research; Master's thesis.
(*e*) The project dealt with the determination of parameters influencing the quality of water from strip-mined sites. Data was obtained from a watershed that was instrumented for precipitation, stream flow and water quality both before mining began and during mining. The data was used to derive linear relationships between a water quality parameter and the area disturbed by mining, temperature and current and antecedent precipitation. The water quality parameters studied were sulfate, calcium, alkalinity, turbidity and conductance. A similar formula was also derived for discharge. A correlation analysis was also made between the various water quality parameters.
(*f*) Completed.
(*g*) The relationship for each water quality parameter was derived for conditions before mining and during mining. The coefficients in the relationships were optimized for minimum error. These coefficients indicate that temperature is not an important term except in the case of alkalinity. Also, in most cases, surface runoff is the basic mechanism of removal of the substance from the disturbed area into the stream.

171-09168-810-33

A FINITE-ELEMENT MODEL TO ASSESS THE HYDROLOGIC IMPACT OF VARIOUS LAND-USE PRACTICES

(*b*) Office of Water Resources Research.
(*c*) D. N. Contractor, Asst. Professor, Civil Engrg. Dept.; V. O. Shanholtz, Asst. Professor, Agricultural Engrg. Department.
(*d*) Theoretical; applied research; Master's thesis.
(*e*) A computer model will be developed to predict changes in flood levels due to changes in land use. The model will combine the computational features of hydrologic and hydraulic programs with land use planning data. It will be developed as a planning and management device for the South River watershed project near Waynesboro, Virginia. The project is a cooperative effort of state and local government which is being coordinated by the fifth regional planning district. The main land use practices of concern are forestation, cropping and urbanization. The plan involves the development of a hydrologic model based on infiltration theory and the kinematic wave approximation to overland flow to provide a detailed understanding of the hydrologic impact of land-use changes.

171-09169-040-00

CAVITY FLOW PAST AN OBSTACLE INCLUDING GRAVITY EFFECTS

(*c*) D. N. Contractor, Assistant Professor.
(*d*) Theoretical; applied research, Doctoral thesis.
(*e*) To use the relaxation method to find the solution of cavity flow past a two-dimensional roughness element at the bottom of an open channel with gravity effects included. The method is based on an inviscid, irrotational and incompressible flow field, using a finite-difference representation of Laplace's equation with the stream function as the dependent variable. The free-surface and cavity boundaries were adjusted systematically to satisfy the appropriate boundary conditions. The Helmholtz-Kirchhoff cavity model was used.
(*f*) Completed.
(*g*) The cavity model chosen was such that all mathematical conditions were satisfied easily. However, its usefulness was limited because it was not possible to determine a finite cavity length behind the roughness element.

171-09170-860-33

MATHEMATICAL MODELING OF STREAMFLOW AND WATER QUALITY IN THE UPPER REACHES OF THE CHOWAN RIVER

(*b*) Office of Water Resources Research.
(*c*) D. N. Contractor, Asst. Professor.
(*d*) Theoretical; applied research; Master's thesis.
(*e*) In recent years, the estuarine portion of the Chowan River has shown several occurrences of algal blooms. In order to study, control and eliminate these occurrences, a joint effort by state agencies and universities is currently being undertaken. An attempt will be made to quantify the nutrient inputs and flow quantities and to develop a predictive model that can be used for management purposes. Two computer programs will be developed; one to predict the flow in the river including wind effects and the second one to predict the levels of nitrogen in the river and the consequent dissolved oxygen.

171-09171-810-00

NUMERICAL SIMULATION OF SURFACE RUNOFF FROM SMALL DRAINAGE AREAS

(*c*) J. M. Wiggert, Assoc. Professor.
(*d*) Theoretical and numerical study, Doctoral thesis.
(*e*) An implicit finite-difference method was used to solve the equations for surface runoff and streamflow. Linking of the solutions was to be accomplished. A natural watershed was used to experimentally apply varying storm configurations in a numerical sense.
(*f*) Completed.
(*g*) It was found that time of concentration is dependent upon rainfall intensity and basin slope. Other, similar conclusions were reached regarding basin shape.
(*h*) *Ph.D. Dissertation*, F. L. McConnell.

171-09172-300-60

TECHNIQUES FOR OPTIMIZING PARAMETERS IN THE IMPLICIT METHOD OF RIVER ROUTING

(*b*) Virginia Water Control Board, Division of Water Resources.
(*c*) J. M. Wiggert, Assoc. Professor.
(*d*) Theoretical and numerical, partially Master's thesis.
(*e*) River parameters (cross-section and flood plain geometry and roughness) are at best rather arbitrary averages when used to describe characteristics of a reach of river. A method of optimization of those parameters is being sought. A good value of the parameter is one which gives a minimum error in discharge values. Various search techniques are being used. Extensions are intended to include the effect of parameters in reaches other than the one where performance is being evaluated, and optimizing on stage rather than discharge.

171-09173-300-00

FLOW ROUTING IN REVERSE DIRECTIONS BY THE IMPLICIT METHOD

(*c*) J. M. Wiggert, Assoc. Professor.
(*d*) Theoretical and numerical study.
(*e*) Flow routing in the x-t plane in an implicit formulation was done in the negative sense, computing from later time to earlier time, and from a downstream position to an upstream position. The purpose of the project was to determine whether it is possible to specify upstream discharges from a reservoir source in order to achieve a specific condition downstream under transient conditions.
(*f*) Completed.
(*g*) It was found that the project purpose could be accomplished in computation in the negative x-direction sense, but not in the negative t-direction due to non-convergence. It was also found that computation in the positive x-direction was non-convergent.
(*h*) **Reverse Flow Routing by the Implicit Method,** R. N. Eli, II, J. M. Wiggert, D. N. Contractor, *Water Resour. Res.* **10,** 3, pp. 597-600, June 1974.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, College of Engineering, Department of Engineering Science and Mechanics, Blacksburg, Va. 24061. Dr. Daniel Frederick, Department Head.

172-08357-480-50

THE MEASUREMENT OF THE GROUND WIND STRUCTURE

(*b*) National Aeronautics and Space Administration.
(*c*) Assoc. Professor Henry W. Tieleman.
(*d*) Experimental and theoretical research.
(*e*) Research program concerned with the measurements of the ground winds in the atmospheric boundary layer. Mean velocities and mean temperature as well as all statistical quantitiess describing the fluctuating components are obtained at six different levels with instruments mounted on the 250-foot meteorological tower at the NASA-Wallops Flight Center. A special F.F.T. algorithm was developed for the spectral analysis in the frequency range from 0.05 to 100 Hertz.
(*f*) At the present, the software phase is completed and the system has been developed to a stage where data can be taken with six instruments simultaneously.
(*h*) **Simulation of a Set of Correlated High Wind Velocities,** M. Hoshiya, H. W. Tieleman, *Proc. 28th Ann. Conf. Japan Soc. Civil Engrs.*, pp. 807-810, Nov. 1972.

An Evaluation of the Three-Dimensional Split-Film Anemometer for Measurements of Atmospheric Turbulence, H. W. Tieleman, K. P. Fewell, H. L. Wood, *VPI-E-73-9 (NASA-CR-62093)*, available NTIS.

Statistical Analysis of Low Level Atmospheric Turbulence, H. W. Tieleman, W. W. L. Chen, *VPI-E-74-3 (NASA-CR-137456)*, available NTIS.

A Method for the Measurement and the Statistical Analysis of Atmospheric Turbulence, H. W. Tieleman, S. C. Tavoularis, *VPI-E-74-26.*

172-09174-000-14

EXPERIMENTAL INVESTIGATION OF UNSTEADY SEPARATION

(*b*) U. S. Army Research Office.
(*c*) D. P. Telionis, Assoc. Professor, D. J. Schneck, Asst. Professor.
(*d*) Experimental, basic research.
(*e*) An experimental project involving the building of a low speed water tunnel designed to operate with glycerin mixtures. Flow visualization techniques will be employed to study unsteady viscous flow phenomena and separation. This is basic research and parts of it will be included in Master's and Doctoral dissertations.
(*g*) Water tunnel is now under construction.

172-09275-010-26

UNSTEADY TURBULENT BOUNDARY LAYERS AND SEPARATION

(*b*) USAF Office of Scientific Research.
(*c*) D. P. Telionis, Assoc. Professor.
(*d*) Theoretical, basic research.
(*e*) Numerical investigation of time dependent turbulent boundary layers. Eddy viscosity models are generalized to account for dynamic effects. Theoretical predictions are compared with experimental data. The phenomenon of unsteady separation is also investigated.
(*g*) It appears that the present models predict pretty accurately the phenomenon for relatively high frequencies. The flow shows a small phase advance with respect to the outer field. This phase angle tends to values of 30° - 40° on the wall which implies that the skin friction is in phase advance with respect to the outerflow oscillations.
(*h*) **Unsteady Turbulent Boundary Layers and Separation,** D. P. Telionis, D. Th. Tsahalis. Presented *13th AIAA Aerospace Sci. Mtg., Paper No. 75-27*, Pasadena, Calif., 1974.

172-09176-290-20

SUPERSONIC WIND-GENERATED WAVES

(*b*) Office of Naval Research.
(*c*) Dr. Ali H. Nayfeh.
(*d*) Theoretical and experimental basic research.
(*e*) Work is being done in connection with transpiration cooling. A systematic approach is being used to develop a method of predicting the observed wave lengths and their corresponding wave speeds and amplitudes on the surface of a liquid film adjacent to a supersonic stream. A computer code has been written and debugged for calculating the pressure and shear perturbations exerted by a compressible stream past a wavy wall. The analysis is not restricted for mean flows that are linear within the disturbance sublayer. The results show that significant error can be introduced if the mean flow is assumed to be linear in the disturbance sublayer especially for turbulent boundary layers. The pressure and shear perturbations calculated from this improved gas model are incorporated into the computer code that calculates the linear stability of the liquid film. Numerical calculations are being generated for comparison with the available experimental data.
(*h*) **Stability of Non-Parallel Flows,** *Arch. Mech.* **26**, 3.
Nonlinear Stability of a Liquid Film Adjacent to a Viscous Supersonic Stream, submitted for publication, *J. Fluid Mech.*
Stability of Liquid Films Adjacent to Compressible Streams, submitted for publication, *J. Engr. Sci.*
Non-Parallel Stability of Boundary-Layer Flows, submitted for publication, *The Physics of Fluids.*

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VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, Department of Mechanical Engineering, Blacksburg, Va. 24061. Dr. J. B. Jones, Department Head.

173-07750-010-14

TURBULENCE PROPERTIES IN STRONGLY SKEWED THREE-DIMENSIONAL BOUNDARY LAYERS

(*b*) Army Research Office – Durham.
(*c*) Dr. F. J. Pierce, Professor.
(*d*) Experimental.
(*e*) All six elements of the Reynolds stress tensor have been measured in the skewed end-wall boundary layer of a curved channel flow, and the skewed, pressure driven boundary layer on a flat plate generated by free streamline curvature.
(*f*) Completed.
(*g*) Fair to good agreement between two of the measured shear stresses and the streamwise and transverse stresses calculated for the secondary flow field using an isotropic mixing length model was found.
(*h*) **Measurements of the Reynolds Stress Tensor in a Three-Dimensional Turbulent Boundary Layer,** F. J. Pierce, S. H. Duerson, Jr., *Interim Tech. Rept. No. 4*, ARO-D Project 6858E, Feb. 1971; *VPI and SU Coll. of Engrg. Rept. VPI-E-74-4.*

173-08358-010-00

NUMERICAL SOLUTIONS TO THREE-DIMENSIONAL TURBULENT FLOWS

(*c*) Dr. F. J. Pierce, Professor.
(*d*) Analytical, basic research.
(*e*) Finite difference solution techniques are being applied to predict the flow and stress field behavior of a shear-driven three-dimensional turbulent boundary layer. Elliptic or diffusion-type terms considering upstream propagation of downstream effects are being treated as well as different turbulent stress models.

173-08361-600-00

A STUDY OF JET REATTACHMENT IN BISTABLE FLUIDIC DEVICES

(*c*) Dr. E. F. Brown, Asst. Professor.
(*d*) Experimental; applied research for Master's thesis.
(*e*) The problem of jet interaction in a simplified model of a Corning bistable fluid amplifier was examined. The total pressure profiles and the location of the reattachment point of the supply jet were experimentally determined at several control-jet mass-flow rates. Reasonable agreement between these results and a theoretical prediction of the location of the reattachment point was observed.
(*f*) Completed.
(*g*) An apparent acceleration of the rate of development of the supply jet was observed with increasing control-jet mass-flow rate. Experiments revealed that theoretical prediction of the reattachment point location could be improved if the undeveloped portion of the supply jet and the asymmetrical character of its velocity profile were taken into account.
(*h*) **Jet Interaction In a Simplified Model of a Bistable Fluid Amplifier,** E. F. Brown, F. C. Belen, Jr., *Fluidics Quart.* 5, 2, pp. 84-95, Apr. 1973.

173-08362-700-70

A SPECTROPHOTOMETER FOR THE MEASUREMENT OF LOCAL DENSITY IN A FLOWING GAS

(*b*) E. I. du Pont de Nemours and Company.
(*c*) Dr. E. F. Brown, Asst. Professor.

(*d*) Experimental; applied research for Master's thesis.
(*e*) Development of a method for the measurement of air density in a wind tunnel. The technique of infrared absorption spectroscopy will be used and the value of the density will be obtained from the radiation absorbed from a 4.28μ source. Plans include the design of a servo-controlled beam-positioning and read-out system to permit contours of constant density to be automatically drawn by an x-y recorder.
(*f*) Completed.
(*g*) The spectrophotometer was used to make local density measurements in the thermal boundary layer of a heated vertical flat plate in a four-percent carbon dioxide/air mixture. The measured density values were within 2.5 percent of the theoretical density values for all but the point closest to the plate. The increased error near the plate was due to changes in the absorptivity of the gas mixture as the temperature of the gas increased.
(*h*) **Development of a Method for Measuring Local Density in a Flowing Gas,** M. D. Rorrer, *Master's Thesis*, Mech. Engrg. Dept., Va. Poly. Inst. and State Univ., Jan. 1973.
Development of a Method for Measuring Local Density in a Flowing Gas, E. F. Brown, M. D. Rorrer, *ASME Paper No. 74-WA/HT-37*, Nov. 1974.

173-08363-030-00

THE INTERACTION OF THE WAKE OF A CYLINDER AND A FLAT-PLATE BOUNDARY LAYER

(*d*) Experimental; basic research partly for Doctoral thesis.
(*e*) A basic study has been made of the incompressible flow field 80 and more diameters downstream from a circular cylinder which is located with its axis normal to a flat plate on which a zero-pressure-gradient boundary layer is developing. The cylinder diameter is less than the boundary layer thickness, and the cylinder is essentially infinite in length.
(*f*) Nearly completed.
(*g*) Secondary flows initiated by the stagnation pressure gradient on the upstream face of the cylinder affect the velocity distribution in the wake-boundary layer interaction region within approximately 100 cylinder diameters downstream of the cylinder. The interaction region as far as 200 diameters downstream has characteristics which are those of wakes and boundary layers in approximately equal proportions.

173-08364-600-70

PROBLEMS IN FLUIDICS

(*b*) Corning Glass Works.
(*c*) Dr. H. L. Moses, Assoc. Professor.
(*d*) Experimental and analytical; applied research for Master's theses.
(*e*) Develop information for the design of fluidic devices and circuits. The current work includes a study of signal transmission in integrated circuits and a study of the effects of power nozzle design in gate performance.
(*f*) Completed.
(*g*) Experiments have been conducted on fluidic signal transmission in tubing and rectangular channels. Studies have also been conducted on the effect of power nozzle design and other geometric parameters on fluid amplifier performance.
(*h*) **Engineering Approximations for Fluidic Interconnections,** H. L. Moses, R. A. Comparin, *Proc. HDL Fluidic State-of-the-Art Symp.*, Oct. 1974.
The Effect of Geometric and Fluid Parameters on Static Performance of Wall-Attachment-Type Fluid Amplifiers, H. L. Moses, R. A. Comparin, *Proc. HDL Fluidics State-of-the-Art Symp.*, Oct. 1974.

173-08366-010-00

NUMERICAL SOLUTION OF THE TURBULENT BOUNDARY LAYER EQUATIONS FOR CORNER FLOW

(*c*) Dr. H. L. Moses, Assoc. Professor.
(*d*) Analytical; basic research for Doctoral thesis.
(*e*) A numerical procedure was developed for computing the boundary layer development along a corner with constant pressure. For the turbulent case, a simple eddy viscosity model was used to account for the shear stress in two directions. An empirical relation was developed and used along with the continuity and longitudinal momentum equation to determine the three velocity components.
(*f*) Completed.

173-08367-550-20

INVESTIGATION OF PRESSURE FLUCTUATIONS AND STALLING CHARACTERISTICS ON ROTATING AXIAL-FLOW COMPRESSOR BLADES

(*b*) Office of Naval Research – Project SQUID.
(*c*) Dr. W. F. O'Brien, Assoc. Professor; Dr. H. L. Moses, Assoc. Professor.
(*d*) Experimental and analytical; applied research for Master's and Doctoral theses.
(*e*) Radio-telemetry techniques have been developed for the transmission of flow data from the rotating blades of an axial-flow compressor. Of special interest are the blade surface pressures under off-design and stall conditions. The analytical approach includes the inviscid flow and boundary layer interaction.
(*g*) A six-channel telemetry system has been developed for the simultaneous transmission of six pressure signals from transducers embedded in the rotor blade. Chord-wise pressure distributions (both mean and fluctuating) have been measured at different radial positions for various flow rates, including stall. Current experiments are conducted on a relatively low-speed compressor. A new high-speed research facility is under construction which will provide for similar experiments on state-of-the-art compressor rotors.
(*h*) **Pressure Measurements On the Rotating Blades of An Axial-Flow Compressor,** M. R. Sexton, W. F. O'Brien, H. L. Moses, *ASME Paper No. 73-GT-79*, Apr. 1973.
The Chord-Wise Pressure Distribution on a Rotating Axial-Flow Compressor Blade, H. L. Moses, W. F. O'Brien, *Proc. 2nd Intl. Symp. Air Breathing Engines*, Sheffield, England, Mar. 1974.
A Multi-Channel Telemetry System for Flow Research on Turbomachine Rotors, W. F. O'Brien, H. L. Moses, H. R. Carter, *ASME Paper No. 74-GT-112*, Apr. 1974.

173-09184-550-70

TRANSONIC NOZZLE FLOW METHODS

(*b*) Douglas Aircraft Co., McDonnell Douglas Corporation.
(*c*) Dr. E. F. Brown, Asst. Professor.
(*d*) Theoretical; applied research for Master's thesis.
(*e*) Develop a fast and accurate computational method for predicting the performance of aircraft propulsion nozzles using the method of type-dependent relaxation.
(*g*) For a convergent-divergent nozzle of hyperbolic geometry the calculated lines of constant Mach number were in excellent agreement with a previously published series expansion solution. These results were obtained in approximately one-tenth of the time which would be required for a solution by time dependent methods.
(*h*) **An Application of Relaxation Methods to Transonic Nozzle Flow,** K. E. Walsh, *Master's Thesis*, Mech. Engrg. Dept., Va. Poly. Inst. and State Univ., Sept. 1974.
A Survey of Methods for Exhaust-Nozzle Flow Analysis, E. F. Brown, G. L. Hamilton, *AIAA Paper No. 75-60*, Jan. 1975.

173-09185-000-54

NEAR-WALL SIMILARITY IN THREE-DIMENSIONAL FLOWS

(*b*) National Science Foundation.
(*c*) Dr. F. J. Pierce.
(*d*) Experimental.
(*e*) Direct measurements of local wall shear stress with velocity field data emphasizing near-wall measurements

and pressure field data will be studied to determine the existence and limits on hypothesized near wall similarity in three-dimensional turbulent flows.

173-09186-600-12

RESEARCH AND INVESTIGATION OF THE EFFECT OF FLUID CONTAMINANTS ON FLOW FIELDS AND PERFORMANCE CHARACTERISTICS OF LAMINAR PROPORTIONAL AMPLIFIERS

(*b*) Harry Diamond Laboratories.
(*c*) Dr. H. L. Moses, Assoc. Professsor.
(*d*) Experimental; applied research for Master's thesis.
(*e*) Experiments were conducted on a large-scale laminar proportional amplifier in which known amounts of oil vapor and dust were introduced into the supply air.
(*f*) Completed.
(*g*) Gain curves were recorded at different times after the contaminants had been introduced into the supply at a known rate. Photographs were taken of the contaminant deposits at different points in the amplifier.
(*h*) **Contaminantion Effects in a Laminar Proportional Amplifier**, R. A. Comparin, H. L. Moses, E. E. Rowell, *Proc. HDL Fluidics State-of-the-Art Symp.*, Oct. 1974.

173-09187-600-12

INVESTIGATION OF THE EFFECTS OF GEOMETRICAL CHANGES DUE TO CONTAMINATION ON FLUIDIC COMPONENT PERFORMANCE

(*b*) Harry Diamond Laboratories.
(*c*) Dr. H. L. Moses, Assoc. Professor.
(*d*) Experimental; applied research for Master's thesis.
(*e*) Experiments are being conducted on a fluid amplifier in which there are known amounts of contaminant deposits at different points. An effort is being made to correlate changes in performance with these geometrical changes.

WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulic Laboratory, Department of Civil and Environmental Engineering, Pullman, Wash. 99163. Professor John A. Roberson, Laboratory Head.

174-0325W-810-33

MODEL DEVELOPMENT AND SYSTEMS ANALYSIS OF THE YAKIMA RIVER BASIN

See Water Resources Research Catalog **8**, 6.1347.
(*c*) Howard D. Copp.
(*f*) Completed.

174-08375-210-54

FLOW IN ROUGH CONDUITS

(*b*) National Science Foundation.
(*d*) Experimental and theoretical; basic research for M.S. and Ph.D. theses.
(*e*) By considering the equations governing resistance of a smooth boundary, the drag of roughness elements, the velocity distribution according to Prandtl's mixing length theory and the concentration and size of roughness elements, it is possible to obtain a solution for uniform flow in roughened conduits.
(*g*) The theory has been found to be valid for artificially roughened conduits, for natural streams with rock beds, and for vegetated channels.
(*h*) **A General Theory for Flow in Rough Conduits**, J. A. Roberson, M. Bajwa, S. J. Wright, *J. Hyd. Res., IAHR* **2**, 1974.
The Theory of Flow Resistance for Vegetated Channels, G. T. Thompson, *Ph.D Thesis*, Wash. State Univ., 1974.
Turbulence in the Wakes of Roughness Elements, C. K. Chen, J. A. Roberson, *J. Hyd. Div., Proc. ASCE* **100**, HY1, Jan. 1974.

174-09188-030-54

BI-STABLE FLOW BEHIND RODS

(*b*) National Science Foundation.
(*d*) Experimental basic research; M.S. thesis.
(*e*) When a rod is located near the end of sidewalls there exists the possibility of wake ventilation. When such a configuration exists, bi-stable flow can occur.
(*g*) Bi-stable flow was found to occur with square rods, flat plates, and circular cylinders placed between extended walls of a wind tunnel. The position of the bodies relative to the ends of the walls was a critical factor in producing bi-stable flow. The two states of flow are "closed condition" where the normal vortex shedding occurs, and "open condition" where wake ventilation causes the dividing streamlines to separate permanently.
(*h*) **Bi-Stable Flow Past Square Rods, Plates, and Circular Cylinders**, J. Gibson, *M.S. Thesis*, Wash. State Univ., Jan. 1975.

174-09189-280-60

AIR ENTRAINMENT CHARACTERISTICS OF PLUNGING WATER JETS

(*b*) Washington State Department of Ecology.
(*c*) Alan F. Babb, Assoc. Hydraulic Engineer; Walter C. Mih, Assoc. Hydraulic Engineer.
(*d*) Experimental; basic research; M.S. thesis.
(*e*) Study of the air entrainment characteristics of plunging water jets. The motivation behind the research is to develop information that will assist in the understanding of the air entrainment process of spillway flow. Laboratory facilities have been constructed to produce both two- and three-dimensional jets. Methods have been developed to measure air concentration using the principles of gamma-ray attenuation and hot film anemometry. A procedure for measuring the quantity of entrained air rising through the surface has also been developed.

174-09190-350-73

HYDRAULIC STUDIES OF THE ROCK ISLAND DAM POWERHOUSE ADDITION

(*b*) Public Utility District No. 1 of Chelan County, Washington.
(*c*) Alan F. Babb, Assoc. Hydraulic Engineer.
(*d*) Experimental, applied research; development.
(*e*) A 1:75 scale model is being used to assist in the design of a powerhouse addition at the existing Rock Island Dam on the Columbia River. Objective of the study is to position the powerhouse with special consideration given to passage of anadromous fish by the dam, power output, construction cost, and navigation by the dam.
(*h*) **Hydraulic Model Studies of a Second Powerhouse at Rock Island Hydroelectric Project**, A. F. Babb, *Bull. 326*, WSU Engrg. Ext. Service, 1972.

174-09191-370-65

HYDRAULIC STUDIES OF A ROADWAY BRIDGE CROSSING OF CHELAN RIVER

(*b*) Chelan County Engineers Office.
(*c*) A. F. Babb, Assoc. Hydraulic Engineer.
(*d*) Experimental; applied research; development.
(*e*) The hydraulic interaction of a proposed roadway crossing of Chelan River with an existing railroad crossing and powerhouse tailrace channel is being studied with a movable bed model constructed on a scale of 1:48. Scour, deposition, and flow patterns are being studied in the project area, near the confluence of the Chelan and Columbia Rivers.

174-09192-360-75

SPINNEY MOUNTAIN SPILLWAY PROJECT

(*b*) R. W. Beck and Associates.
(*c*) A. F. Babb, Assoc. Hydraulic Engineer; D. W. Hudspeth, Asst. Hydraulic Engineer.
(*d*) Experimental; applied research; development.

(*e*) The main thrust of the study is to assist in the development of a structure to function both as a stilling basin and a flip bucket.

174-09193-810-33

INVESTIGATION OF THE HYDROLOGY OF SEVERAL RECREATIONAL LAKES OF EASTERN WASHINGTON

(*b*) Office of Water Research and Technology.
(*c*) Howard D. Copp, Assoc. Hydraulic Engineer.
(*d*) Experimental; field investigation; applied research.
(*e*) Many small lakes in Eastern Washington State are being used principally for recreation. This and other land use pressures are generating eutrophication processes. To assist in identifying means of reducing these processes, experimental and analytical activity is being conducted to learn more about the hydrology of these lake basins.
(*g*) Wathershed characteristics of three basins have been mapped based on field surveys. Very little hydrologic data are available in any of the basins so field measurements are being made. Some measurements, already made, verify runoff predictions based on geomorphic watershed characteristics.

174-09194-810-60

SILVER LAKE EUTROPHICATION – CURRENT PROBLEMS AND POSSIBLE SOLUTIONS

(*b*) Washington State Department of Ecology.
(*c*) Howard D. Copp, Assoc. Hydraulic Engineer; Surinder K. Bhagat, Environmental Engineer.
(*d*) Field investigation; theoretical; applied research.
(*e*) Silver Lake, in Western Washington State, is rather severely polluted although in early stages of eutrophication. Pollution sources, both point and nonpoint, are being inventoried and a water balance for the lake watershed is being developed. These bits of information will then be used to generate alternative actions to reduce eutrophication processes as much as possible.
(*g*) Progress to date on the water balance development has included a preliminary determination of watershed characteristics related to the runoff process. Using the geomorphic characteristics and empirical equations recently developed by this office, runoff predictions have been made. Field measurements have shown the predictions to be quite accurate and reliable. Refinement to the predictions and new forecasts are planned. These, with other predicted and measured parameters in the water balance equations, will ultimately create a mean monthly inflow-outflow water quantity formulation.

174-09195-350-75

AMERICAN FALLS SPILLWAY PERFORMANCE MODEL STUDIES

(*b*) Bechtel, Incorporated, San Francisco.
(*c*) John A. Roberson, Hydraulic Engineer; Howard D. Copp, Assoc. Hydraulic Engineer.
(*d*) Experimental; applied research; design.
(*e*) The American Falls Dam, on the Snake River in Southern Idaho, has deteriorated as a result of apparent chemical interaction of water and concrete. The project will be rebuilt to restore its full capacity. Hydraulic model studies were undertaken to examine the performance of the spillway stilling basin and the effects of downstream flow on existing and new structures.
(*f*) Complete.
(*g*) Three distinct but related design plans were studied. One utilized existing structural components as much as possible, but it created undue forms on certain bridge piers. A second plan changed major flow direction near the piers and relaxed the forces, but the plan would require considerable new construction. The third plan used the basic idea of the second but relaxed the extent of new construction. The latter plan incorporated a separate control weir well below the stilling basin to create adequate backwater at the basin for a suitable hydraulic jump.
(*h*) **Hydraulic Model Studies of the American Falls Spillway Flow,** H. D. Copp, Coll. of Engrg., Wash. State Univ., July 1974.

174-09196-340-73

HYDRAULIC MODEL STUDIES OF ROCK TRAPS – HELMS PUMPED STORAGE PROJECT

(*b*) Pacific Gas and Electric Company.
(*c*) Claud C. Lomax, Hydraulic Engineer.
(*d*) Experimental; applied research.
(*e*) A model study will be made of flow conditions at the rock trap for the unlined tunnel. Steady state conditions will be studied which represent various fixed times in the transients associated with the surge tank operations. A larger model will be used to study the effectiveness of the rock trap. Various sizes of rocks will be inserted in the tunnel for trapping. The model ratios will be approximately 1:27 and 1:78 for the flow model and trap model, respectively.

174-09197-800-33

INSTREAM FLOW NEEDS IN THE PACIFIC NORTHWEST: A REGIONAL STUDY OF INSTITUTIONAL AUTHORITY, METHODOLOGY AND INFORMATION RETRIEVAL

(*b*) Office of Water Research and Technology.
(*d*) Assessment of the legal, political, biological, and engineering aspects.
(*e*) To address the work which has been done and is planned, on the problem of reserving flows in streams for such needs as fisheries, recreation, and aesthetics. The analysis of this regional problem includes a collection, collation, assessment of legal, political and methodological components of the total problem. Workshops for practitioners have been held and an information dissemination system for this user group is being developed.
(*g*) Numerous operational problems have been identified through the workshops, questionnaires and personal interviews. A few of these include lack of communication and coordination between regional program participants in state and federal agencies, as well as within agencies and within states; the need for incremental flow methodology to evaluate tradeoffs for competing uses of the stream; new laws without funds to enforce, and short time frames within which to preserve flows; and a lack of quantification of flow diversions out-of-stream.
(*h*) Report on workshops held in Sept. and Oct., 1974, for distribution to participants, Jan. 1975.
Project Report to OWRT, Apr. 15, 1975.
Reports will be available from State of Washington Water Research Center, Wash. State Univ., Pullman, Wash. 99163.

174-09198-860-60

HYDRAULIC AND WATER QUALITY RESEARCH STUDIES AND ANALYSIS OF CAPITOL LAKE SEDIMENT AND RESTORATION PROBLEMS, OLYMPIA, WASHINGTON

(*b*) Washington State Department of General Administration.
(*d*) Field; laboratory; hydraulic model and computer model analysis.
(*e*) The first phase of the study has dealt with an analysis of the sediment entering Capitol Lake from the Deschutes River. Hydraulic model studies have been conducted to determine how to dredge the Upper Lake to trap sediment and keep it out of the Middle and Lower Lakes. Hydrologic analyses, coupled with hydraulic model dye dispersion and detention studies will provide water quantity information for the water quality prediction model. Field tests of bottom muds and water quality conditions have been conducted by the Environmental Research Section.
(*g*) Design geometry for dredging the Upper Lake to trap sediment has been determined through field and hydraulic model studies. Also, method of estimating future sediment load based on precipitation for accounting procedures of maintenance dredging have been determined. Dredging of

the rest of the lake will be done to depths needed to remove nutrientcrich bottom muds, to minimize weed growth, and optimize boating safety and usability.

(*h*) Preliminary Report on a **Sediment Removal and Maintenance System for the Upper Basin of Capitol Lake, Olympia, Washington**, Aug. 15, 1974; **Supplement No. 1**, Sept. 6, 1974, **Supplement No. 2**, Sept. 13, 1974, W. C. Mih, J. F. Orsborn; **Summary Report**, Dec. 20, 1974, J. F. Orsborn.

174-09199-800-88

WATER RESOURCES OF THE COEUR D'ALENE INDIAN RESERVATION

(*b*) Coeur d'Alene Indian Tribal Council.
(*d*) Field, laboratory, and analytical investigation.
(*e*) The various phases of the project include the determination areal precipitation distribution; gaged and ungaged stream flows in subbasins; floods, average and low flows; geologic investigations; well testing; analysis of groundwater level records; summary of existing water rights; and potential water resources available.
(*g*) Field data acquisition is complete and analytical work is underway.
(*h*) Final project report due June 30, 1975.

174-09200-030-54

EFFECTS OF TURBULENCE ON DRAG AND VIBRATION OF ANGULAR BODIES

(*b*) National Science Foundation.
(*d*) Experimental basic research; M.S. and Ph.D. theses.
(*e*) Investigate the effect of free-stream turbulence on the pressure distribution, drag and vibration of angular bodies.
(*g*) Results indicate turbulence can either cause an increase or decrease in drag depending upon the shape of the body. Also, recent results indicate an abnormally extreme negative pressure is found on the forward part of windward walls of building shapes when subjected to winds at low angles of attack. Turbulence generally causes an attenuation of vibration; however, at certain intensities of turbulence for certain shapes the trend is reversed.
(*h*) **Turbulence Effects on Drag of Sharp-Edged Bodies,** J. A. Roberson, C. Y. Lin, G. S. Rutherford, *J. Hyd. Div., Proc. ASCE* **98,** HY7, July 1972.
Aerolastic Vibrations of Structural Shapes in Highly Turbulent Flows, A. N. R. Barriga, *M.S. Thesis*, Wash. State Univ., 1973.
Are the Codes Safe for Wind Pressures?, C. T. Crowe, A. Barriga, J. A. Roberson, W. V. Taylor, *J. Structural Div., Proc. ASCE Paper 1072*, Aug. 1974.
The Effect of Turbulence on the Drag Coefficient of Basic Building Shapes, D. W. Hudspeth, *M.S. Thesis*, Wash. State Univ., 1973.
The Aeroelastic Instability of the Square and H-Shaped Sections in Turbulent Cross Flow, C.-K. Tai, *M.S. Thesis*, Wash. State Univ., 1974.

UNIVERSITY OF WASHINGTON, Department of Civil Engineering, Seattle, Wash. 98195. Professor D. A. Carlson, Department Chairman.

175-08387-450-44

WAVE CLIMATE IN PUGET SOUND

(*b*) Component of a Sea Grant project.
(*c*) Professor E. P. Richey.
(*d*) Field measurement; applied research and development for Master's thesis.
(*e*) Wave spectra are measured at a single site with a four-probe wave array as dependent upon wind direction and speed. Results are to be examined with the view of using the site for large-scale model testing in a natural wave environment.
(*f*) Suspended.

175-08388-870-00

FLUSHING CHARACTERISTICS OF SMALL-BOAT MARINAS

(*c*) Professor R. E. Nece, Director, C. W. Harris Hydraulics Laboratory.
(*d*) Experimental, theoretical, and field investigation; applied research; Master's thesis.
(*e*) A study of tidal flushing and circulation patterns in nearly enclosed small basins. Field data from existing marinas are to be compared with laboratory tidal model results. Relationships between basin configuration and tidal exchange characteristics are to be investigated.

175-08390-870-61

NEAR-FIELD TEMPERATURE DISTRIBUTION FOR THERMAL JETS DISCHARGING INTO FLOWING STREAMS

(*b*) State of Washington Water Research Center.
(*c*) Professor R. E. Nece.
(*d*) Experimental; basic and applied research.
(*e*) Laboratory study to determine empirical relationships defining the near-field temperature distribution and jet trajectory for a buoyant, warm-water jet from a circular horizontal nozzle located near the bottom and discharging at right angles to the direction of flow of a relatively shallow unstratified stream. The range of parameters investigated will characterize typical jets of cooling-water being discharged into well-mixed, wide rivers. (See also, WRRC **8,** 5.2596).
(*f*) Completed.
(*g*) Experimental data obtained for jet densimetric Froude numbers (as conventionally defined) of 5, 10, and 15, combined with jet discharge; cross flow velocity ratios of 0.5, 1, 5, and 20 indicate the velocity ratio to be far more significant in determining the jet behavior than was the Froude number. Parameters tested and reported span ranges commonly encountered in outfall designs.
(*h*) **Round Horizontal Thermal-Buoyant Jet in a Cross Flow,** R. E. Nece, J. D. Littler, *C. W. Harris Hydraul. Lab. Tech. Rept. 34*, June 1973.

175-09201-470-13

LAKE CROCKETT SMALL BOAT BASIN CIRCULATION STUDY

(*b*) Dept. of the Army, Corps of Engineers, Seattle District.
(*c*) Professor E. P. Richey.
(*d*) Experimental; applied research.
(*e*) Comparative exchange and mixing characteristics for four alternative planform geometries for a small boat basin were evaluated using a hydraulic model in which tides and long-shore current were simulated.
(*f*) Completed.
(*h*) **Lake Crockett Small Boat Basin Circulation Study,** E. P. Richey, R. E. Nece, *C. W. Harris Hydraul. Lab. Tech. Rept. 33*, Oct. 1972.

175-09202-430-60

ATTENUATION OF RANDOM DEEP WATER WAVES BY A POROUS WALLED BREAKWATER

(*b*) Washington State Highway Commission, U. S. Dept. Transportation, Federal Highway Administration.
(*c*) Professor E. P. Richey.
(*d*) Theoretical treatment of experimental field data; applied research.
(*e*) Investigation of the response of a field-installed porous walled breakwater to wind waves, with particular focus on the characteristics of the reflected wave field. See also, WRRC **8,** 2.1343.
(*f*) Completed.
(*h*) **Attenuation of Random Deep Water Waves by a Porous Breakwater,** E. P. Richey, D. B. Morden, B. J. Hartz, *C. W. Harris Hydraul. Lab. Tech. Rept. 36*, Aug. 1973.

175-09203-330-75

MODEL STUDY OF CLOSURE OF THE EAST WATERWAY, DUWAMISH RIVER ESTUARY

(*b*) Cornell, Howland, Hayes and Merryfield/Clair A. Hill and Associates, Bellevue, Washington.
(*c*) Professor R. E. Nece.
(*d*) Experimental; applied research.
(*e*) Changes in currents affecting navigation in a waterway, and changes in gross flushing of a waterway due to tidal and river flows, were studies for various proposed closures (complete and partial) of the East Waterway, Duwamish River Estuary, Seattle.
(*f*) Completed.
(*h*) **Hydraulic Model Study of Closure of the East Waterway, Duwamish River Estuary,** R. E. Nece, C. B. Tweedt, E. P. Richey, *C. W. Harris Hydraul. Lab. Tech. Rept. 35*, June 1973.

175-09204-470-60

RELATIONSHIP OF FLUSHING AND WATER QUALITY CHARACTERISTICS OF SMALL-BOAT MARINAS

(*b*) State of Washington Water Research Center (1973-74); State of Washington Department of Ecology (1974-75).
(*c*) Professor R. E. Nece.
(*d*) Experimental and field investigation; applied research.
(*e*) Determine to what extent tidal flushing characteristics of enclosed small-boat marinas can be related to water quality within the marinas, and more specifically, to determine how well the marina flushing characteristics as determined from small-scale hydraulic models serve as predictors for relative alterations in significant water quality parameters. Existing marinas in Puget Sound are to be studied through laboratory models to obtain hydraulic performance and by routine field sampling of the quality parameters.
(*h*) **Flushing and Water Quality Characteristics of Small-Boat Marinas,** R. E. Nece, C. R. Knoll, *C. W. Harris Hydraul. Lab. Tech. Rept. 40*, June 1974.

175-09205-430-44

FLOATING BREAKWATER RESEARCH

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Program.
(*c*) Professor E. P. Richey, or Professor B. H. Adee, Dept. of Mechanical Engineering.
(*d*) Experimental and theoretical; both basic and applied research.
(*e*) Studies include design of instrument package for acquisition of field data on performance characteristics of floating breakwaters, data acquisition, and development of a two-dimensional mathematical model for predicting breakwater performance characteristics using the basic theoretical approach.
(*g*) Reported in (h).
(*h*) **Theoretical Analysis of Floating Breakwater Performance,** B. H. Adee, W. Martin, *1974 Floating Breakwaters Conf. Papers*, pp. 21-41, 1974.
Prototype Performance Characteristics of a Floating Breakwater, D. Christensen, E. P. Richey, *1974 Floating Breakwaters Conf. Papers*, pp. 159-181, 1974.

175-09206-430-11

FLOATING BREAKWATER FIELD ASSESSMENT PROGRAM FRIDAY HARBOR, WASHINGTON

(*b*) U. S. Army Coastal Engineering Research Center.
(*c*) Professor E. P. Richey, or Professor B. H. Adee, Dept. of Mechanical Engineering.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) An extension of the basic steps in part (e) of 175-09205-430-44 to a particular site with extensions of theory to examine non-linear aspects and with an initial step in generalizing floating breakwater performance characteristics and design criteria.

175-09207-430-00

FORCES ON A SUBMERGED PLATFORM BREAKWATER

(*c*) Professor E. P. Richey.
(*d*) Experimental; applied research; Master's thesis.
(*e*) Laboratory measurements of forces on a submerged platform breakwater as depending upon relative wave-structure dimensions.

175-09208-820-00

GROUND MOTIONS RESULTING FROM CHANGES IN PIEZOMETRIC HEAD

(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research.
(*e*) Interest is centered upon developing methods for adequately explaining ground deformations, in the near vicinity of water supply wells, that result from both high and low levels of pumping.
(*g*) To date the homogeneous aquifer case for single well pumping has been examined. Basic results were obtained by coupling a single phreatic surface description with Mindlin's deformation solution for point loads in a half space.
(*h*) **Steady State Ground Motions Caused by Single-Well Pumping,** C. B. Brown, S. J. Burges, *Water Resour. Res.* **9**, 5, pp. 1420-1427, 1973.

175-09209-310-60

DATA AND ADMINISTRATIVE CONSIDERATIONS FOR TWO DISTRICT FLOOD PLAIN ZONING

(*b*) State of Washington Department of Ecology.
(*c*) Professor S. J. Burges.
(*d*) Applied research.
(*e*) Research involved compilation and synthesis of information needed to conduct two district flood plain zoning. An uncertainty analysis procedure was developed and illustrated.
(*f*) Completed.
(*h*) **Data and Administrative Considerations for Two District Flood Plain Zoning,** S. J. Burges, J. S. Hillmer, *C. W. Harris Hydraul. Lab. Tech. Rept. 38*, 1974.

175-09210-810-54

ANALYSIS OF TIME SERIES MODELING ERRORS

(*b*) National Science Foundation (Western Forest BIOME).
(*c*) Professor S. J. Burges.
(*d*) Theoretical and applied research; Master's thesis.
(*e*) Research resulted in development of techniques for comparing the faithfulness of replication of simulated flow records derived from use of deterministic precipitation-runoff models. Emphasis was placed upon both graphical display of complete and residual hydrographs as well as on summary statistics of goodness of replication. The general approach is very helpful in locating processes that must be more accurately modeled.
(*h*) **Analysis of Time Series Modeling Errors With Application to the Lake Sammamish Hydrologic System,** C. L. Bates, *M.S. Thesis*, 1974.

175-09211-870-87

OPTIMIZATION OF STORMWATER SEWER SYSTEMS

(*b*) Norwegian Government.
(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research; Doctor's thesis.
(*e*) Determining optimal combinations of major conveyance links and storage elements for stormwater removal systems. The problem involves examination of transient flow and all possible pipe and storage combinations necessary to convey input hydrographs (of any type) without overflowing the system.
(*g*) Implicit four point centered finite difference unsteady flow routing schemes have been found to be suitable for inclusion in a basic dynamic programming formulation of the problem.

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UNIVERSITY OF WASHINGTON, Department of Mechanical Engineering, Seattle, Wash. 98195. Dr. Morris E. Childs, Chairman.

176-09212-270-40

DIAGNOSIS OF INTRAURETHRAL OBSTRUCTIONS BY MEANS OF FLUID DYNAMIC TECHNIQUES

(*b*) National Institutes of Health; Norwich Pharmacal Company.
(*c*) F. B. Gessner, Assoc. Professor.
(*d*) Experimental and theoretical applied research.
(*e*) Analytical and experimental modeling techniques have been applied to examine the feasibility of diagnosing intraurethral obstructions in males by means of catheter withdrawal and pressure pulse techniques. Present studies are oriented toward the design of instrumentation for actual subject studies.
(*g*) Results to date indicate that pulsing the flow immediately downstream of the exit orifice during urination is a promising, non-invasive means of diagnosing intraurethral obstructions.
(*h*) **The Fluid Dynamics of Micturition,** *Investigative Urology* **8,** 3, pp. 324-330, Nov. 1970.
On the Measurement of Local Urethral Resistance (with N. R. Zinner), *Investigative Urology* **8,** 3, pp. 331-339, Nov. 1970.
Pressure Pulse Reflection As a Means of Diagnosing Obstructions in the Lower Urinary Tract (with W. E. Nykvist, N. R. Zinner), *J. Biomech.* **4,** 5, pp. 391-403, Oct. 1971.
Analysis of Pressure Wave Reflection in the Male Urethra for the Purpose of Diagnosing Obstructions (with S. J. Lai-Fook), *J. Fluids Engrg., Trans. ASME* **96,** 4, Dec. 1974.

176-09213-270-40

FLUID MECHANIC BEHAVIOR OF PROSTHETIC VALVES

(*b*) National Institute of General Medical Science (NIGMS).
(*c*) J. E. Jorgensen, Assoc. Professor.
(*d*) Experimental applied research.
(*e*) Experimental *in-vitro* performance investigation of several commercial aortic valve prostheses for comparison with UW-developed trileaflet aortic prothesis in both steady and pulsatile flow. Assessment of valve pressure drop, mean gradient, volume (cardiac) efficiency, regurgitation and stenotic behavior as a function of valve flow.
(*g*) Results for steady flow indicate that performance of trileaflet valves with slight stenosis (35 percent) is comparable to that of commercial valves of the ball or disc type. Pulsatile flow performance of the trileaflet valve appears to be consistently better than that of ball and disc type valves in the functions tested. Relatively short fatigue life is an obstacle at the present time.
(*h*) **Experimental Study of the Steady Flow Through a Prosthetic Trileaflet Aortic Heart Valve** (with J. E. Harris, W. G. Yates, H. Mohri), *ASME Paper No. 73-WA/Bio-19.*
A Fluid Mechanical Test System for Prosthetic Heart Valves, *Proc. 25th ACEMB*, Bal-Harbour, Fla., Oct. 1972.
Variable Pulsatile Flow Simulator, *Proc. 25th ACEMB*, Bal-Harbour, Fla., Oct. 1972.
Pulsatile Pressure and Flow Generation (with J. P. Enz), *FLOW – Its Measurement and Control in Science and Industry* **1,** 3, pp. 1479-86 (W. E. Vannah and H. Wayland, ed.), ISA, 1974.

176-09214-520-54

AN ANALYSIS OF SHIP RESISTANCE

(*b*) National Science Foundation.
(*c*) Bruce H. Adee, Asst. Professor.
(*d*) Theoretical basic research.
(*e*) An attempt to combine the results of a potential-theory analysis and a three-dimensional boundary-layer calculation for theoretically predicting the resistance of a ship at constant forward speed.
(*g*) Results for a limited number of cases have been obtained. Wave-resistance calculations show better agreement with experimental measurements than previous calculations using Michell's integral. Computed estimates of frictional resistance also agree with flat-plate frictional resistance.
(*h*) **Computer-Aided Ship Resistance Calculations** (with P. Harvey), Pacific NW Sect., Soc. Naval Arch. and Mar. Engrs., 8 Mar. 1975.

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UNIVERSITY OF WASHINGTON, Department of Oceanography, Seattle, Wash. 98195. Dr. Maurice Rattray, Jr., Department Chairman.

177-07779-060-26

SHEAR FLOW EFFECTS IN CONSTANT DENSITY AND STRATIFIED FLUIDS

(*b*) Air Force Office of Scientific Research.
(*c*) Professor William O. Criminale, Jr.
(*d*) Theoretical; basic research.
(*e*) Studies include interaction of shear flow and internal waves; initial value problems at the thermocline; turbulence in stratified media; wave breaking; large scale boundary layers.
(*g*) Linearized analysis for all of the above (e).
(*h*) **On Breaking of Internal Gravity Waves,** *Paper No. 5, Proc. Intl. Symp. of Stratified Flow*, Novosibirsk, USSR, Aug. 1972.
On the Asymptotic Structure of Turbulent Transfer Coefficients. Accepted for publication by *Zeitschrift für* Angewandte Mathematik und Mechanik, 1974.
Resonant Interaction of Internal Waves in Linear Shear Flow, K. F. Jones, *M.S. Thesis*, Geophysics Group, Univ. Wash., 1974.

177-07780-060-54

INTERNAL WAVE STUDIES

(*b*) National Science Foundation; Office of Naval Research.
(*c*) Professor M. Rattray, Jr.; L. H. Larsen, Res. Assoc. Professor; S. Martin, Res. Asst. Professor
(*d*) Experimental, theoretical, and field investigations; basic research.
(*e*) Studies of internal wave generation, propagation, dissipation and interactions; *in situ* observations of internal waves in the ocean.
(*h*) **Tides at Cobb Seamount,** L. H. Larsen, J. D. Irish, *J. Geophys. Res.*, Sept. 30, 1974.
Threshold of Sediment Movement by Open Ocean Waves: Observations, R. W. Sternberg, L. H. Larsen, *Deep-Sea Res.*, 1974.
Measurement of Internal Waves of Tidal Frequency Near a Continental Boundary, W. B. Barbee, J. G. Dworski, J. D. Irish, L. H. Larsen, M. Rattray, Jr., *J. Geophys. Res.* **80,** 15, p. 1962, 1975.

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WEBB INSTITUTE OF NAVAL ARCHITECTURE, Crescent Beach Road, Glen Cove, N. Y. 11542. Dr. Edward V. Lewis, Director of Research.

178-07781-520-54

EXPERIMENTAL DETERMINATION OF SHIP WAVE RESISTANCE IN MODEL AND FULL SCALE

(*b*) National Science Foundation (Engineering Mechanics Program).
(*c*) Dr. Lawrence W. Ward, Prof. of Engineering.
(*d*) Experimental and theoretical basic research.
(*e*) Development of methods of direct experimental determination of model or ship wave resistance by measure-

ment of the wave pattern, thereby investigating the problems of optimizing hull forms, improving model to full-scale correlation, and devising a technique for determining full-scale ship wave resistance. Includes theoretical work, experimental work in a model tank, and full-scale tests on a boat off the Webb beach. The project has value in providing a hydrodynamic tool of general scientific interest, a method of understanding better the fundamentals of ship resistance, and a means for furthering graduate and undergraduate education.

(*f*) Complete.

(*g*) Extensive results are now available to establish the region of validity of longitudinal cut wave surveys on a typical ship model. Results show that errors can be expected in such tests at high Froude numbers in narrow tanks, especially when based on lateral slope data. Analysis of prototype tests run offshore on a boat and corresponding model tests show success in removing the effect of ambient sea signal contamination by means of signal averaging in both cases, and some degree of correlation between the boat and model tests but with an apparent channeling effect of the model tank sides in the latter tests. Further offshore tests will be necessary to establish the quantitative nature of the correlation.

(*h*) **Comparison of Wave Measurements on a Full-Scale Boat Offshore with Model Tank Results,** L. W. Ward, R. van Hooff, *Proc. 17th Amer. Towing Tank Conf.*, Calif. Inst. Tech., Pasadena, Calif., June 1974.

Analysis of Wave Survey Experiments on a Boat in Coastal Waters, L. W. Ward, *IEEE "Ocean 72" Conf.*, Newport, R. I., Sept. 1972.

The Effect of Probe Location on a Model Wave Resistance Survey Along a Longitudinal Cut, L. W. Ward, R. van Hooff, *Webb Inst. Naval Arch. Rept.*, Jan. 1974.

178-08398-520-48

STUDIES OF HIGH FREQUENCY SHIP HULL RESPONSE TO WAVES ("Springing")

(*b*) U. S. Coast Guard.

(*d*) Experimental (model) and theoretical; applied research.

(*e*) Tests with a jointed model, having variable natural frequency of vertical two-noded vibration, in regular waves in a model basin. Magnitude of the vertical bending moment excited at different encounter frequencies, particularly at and near resonance, are measured. Theoretical computer calculations are being made and results compared with experiments.

(*g*) Excellent results have been obtained in tests at various speeds in short waves. Calculations give good agreement in certain cases, but more extensive experimental and theoretical work is needed.

(*h*) **Feasibility Study of Springing Model Tests of a Great Lakes Bulk Carrier,** D. Hoffman, R. W. van Hooff, *Intl. Shipbuilding Progress*, Mar. 1973.

Experimental and Theoretical Evaluation of Springing on a Great Lakes Bulk Carrier, D. Hoffman, R. W. van Hooff, *D.O.T., USCG Rept. CG-D-8-74*, July 1973.

178-09216-420-21

ANALYSIS OF OCEAN WAVE SPECTRA FOR APPLICATION TO SHIP DESIGN

(*b*) U. S. Navy, General Hydromechanics Research Program, Naval Ship Research and Development Center.

(*c*) Dr. Dan Hoffman.

(*d*) Theoretical; applied research.

(*e*) Analyzing wave spectra from various ocean weather ships and comparing trends of wave and weather parameters. Developing "families" of spectra of different levels of severity for use in ship design and comparing these with various ideal formulations. Purpose is to provide more reliable ocean wave data and show how they can best be applied in design.

(*g*) Significant trends established, differing from generally-used ideal formulations. Final report in preparation.

(*h*) **Analysis of Measured and Calculated Spectra,** D. Hoffman, *Proc. Intl. Symp. Dynamics of Marine Vehicles and Structures in Waves*, Univ. College, London, Apr. 1974.

Analysis of Wave Records and Application to Design, D. Hoffman, *Proc. Intl. Symp. Ocean Wave Measurement and Analysis*, New Orleans, Sept. 1974.

178-09217-520-45

IMPROVED AUTOMATIC STEERING OF SHIPS

(*b*) National Maritime Research Center (Maritime Administration), Kings Point, N. Y.

(*d*) Experimental; applied research.

(*e*) A model of a fast container ship is arranged for automatic steering in following waves in a towing basin. A PDP-8 minicomputer in the control loop permits changes in the control equations and constants to be made for experimental evaluation. Purpose is to improve quality of steering control in rough seas for modern high-speed ships.

(*g*) Feasibility of test procedure established. Results of successful test runs being analyzed.

(*h*) **A Model Steering Study,** Femenia, Lewis, van Hooff, Zubaly. Report issued by National Maritime Research Center, Kings Point, N. Y.

WESTERN WASHINGTON STATE COLLEGE, Department of Geography, Bellingham, Wash. 98225. Dr. Thomas A. Terich.

179-09218-410-30

COASTAL PROCESSES OF NORTHEASTERN PUGET SOUND: WHATCOM AND SKAGIT COUNTIES

(*b*) U. S. Geological Survey and Washington State Dept. of Natural Resources, Division of Geology and Earth Resources.

(*c*) T. A. Terich, Asst. Professor.

(*d*) Field investigation; applied research.

(*e*) Study of wave heights and directions to determine resultant longshore currents and sediment transport plus shoreline erosion and deposition.

(*g*) Preliminary studies indicate a seasonally reversing longshore sediment transport. Active shore bluff erosion related to wave attack, groundwater and stratigraphy.

UNIVERSITY OF WISCONSIN, Marine Studies Center, 1225 W. Dayton Street, Madison, Wis. 53706. R. A. Ragotzkie, Director.

181-07971-870-44

PHYSICAL ASPECTS OF THERMAL POLLUTION

(*b*) Sea Grant Program and NASA Remote Sensing Program.

(*c*) T. Green.

(*d*) Field, basic research.

(*e*) Measurements are being made of the fine structure of a thermal plume on Lake Michigan.

(*g*) Detailed thermal imagery of the plume surface temperature has been obtained, together with surface velocity data.

181-07972-810-33

RAIN MIXING

(*b*) Office of Water Resources Research.

(*c*) T. Green.

(*d*) Laboratory, basic research.

(*e*) The depth to which rain penetrates a natural water surface is measured as a function of drop size, drop temperature, and ambient water temperature.

181-07973-440-54

COASTAL CURRENTS IN LAKE SUPERIOR

(*b*) National Science Foundation; NASA Remote Sensing Project.
(*c*) T. Green.
(*d*) Field, basic research.
(*e*) Photogrammetric methods are used to determine the fine structure of the velocity of the Keweenaw current.
(*g*) The fine structure can be determined using photogrammetric techniques.

181-07974-440-88

DYNAMICS OF LAKE CURRENTS

(*b*) Argonne National Laboratory.
(*c*) John Bennett.
(*d*) Theoretical; Doctoral thesis.
(*e*) Develop numerical models for flow in the Great Lakes and use them to interpret observations.
(*f*) Completed.
(*h*) **A Theory of Large Amplitude Kelvin Waves,** J. R. Bennett, 1972 AGU Annual Meeting.

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UNIVERSITY OF WISCONSIN, Department of Mathematics, Madison, Wis. 53706. Professor Peter E. Ney, Department Chairman.

182-08400-420-61

WATER WAVES IN THERMALLY STRATIFIED LAKES AND LONG RIVERS

(*b*) National Science Foundation.
(*c*) Professors R. E. Meyer and M. C. Shen.
(*d*) Theoretical; basic and applied research.
(*e*) Off-shore physical oceanography research.
(*h*) **Waves on Beaches and Resulting Sediment Transport,** R. E. Meyer, ed., Academic Press, N. Y., 462 pages, 1972.
Wave Resonance Near Shores, M. C. Shen, in *Waves on Beaches*, Academic Press, N. Y. (R. E. Meyer, ed.), pp. 123-161, 1972.
Run-Up On Beaches, R. E. Meyer, A. D. Taylor, in *Waves on Beaches*, Academic Press, N. Y. (R. E. Meyer, ed.), pp. 357-411, 1972.
Ray Method for Surface Waves on Fluid of Variable Depth, M. C. Shen, Math. Res. Center, Univ. Wis.-Madison, *Tech. Sum. Rept. 1416*, 32 pages, 1974 (to appear in SIAM Review).
Asymptotic Theory of Nonlinear Surface Waves On a Viscous Fluid in An Inclined Channel of Arbitrary Cross-Section, M. C. Shen, S. M. Shih, *Phys. Fluids* **17**, pp. 280-286, 1974.
On the Mechanism of Blocking In a Stratified Fluid, D. D. Freund, R. E. Meyer, *J. Fluid Mech.* **54**, pp. 719-744, 1972.
Note On Lee Waves and Windward Modes, R. E. Meyer, *J. Geophys. Res.* **76**, pp. 7917-18, 1973.
Ray Methods for Nonlinear Wave Propagation In a Rotating Fluid of Variable Depth, M. C. Shen, J. B. Keller, *Phys. Fluids* **16**, pp. 1565-1572, 1973.
Planetary Waves Over the Rotating Earth, M. C. Shen, Math. Res. Center, Univ. Wis.-Madison, *Tech. Sum. Rept. 1448*, 32 pages.

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UNIVERSITY OF WISCONSIN — MILWAUKEE, College of Applied Science and Engineering, Milwaukee, Wis. 53201. Dr. R. G. Griskey, Dean.

183-09219-450-54

WIND-DRIVEN CURRENT WITH VARIABLE EDDY VISCOSITY

(*b*) National Science Foundation (partially).
(*c*) Professor Robert Y. Lai, Energetics Department.
(*d*) Theoretical; applied research; M.S. thesis.
(*e*) Project deals with wind-driven currents in the sea and the Great Lakes with special emphasis on the effects of the variation of eddy viscosity with depth.
(*h*) **Wind-Drift Current With Variable Eddy Viscosity,** R. Y. Lai, D. B. Rao, presented *55th Ann. Mtg. AGU*, 1974.
A Finite Element Lake Model With Variable Eddy Viscosity Coefficient, F. Arrizabalago, *M.S. Thesis*, 1974.

183-09220-030-00

UNSTEADY STOKES FLOW PROBLEM

(*c*) Professor Robert Y. Lai, Energetics Department.
(*d*) Theoretical; applied research.
(*e*) Project deals with the drag and the motion of an axisymmetric body accelerating rectilinearly in a Newtonian fluid or a non-Newtonian fluid.
(*h*) **Translatory Accelerating Motion of a Circular Disk in Viscous Fluid,** R. Y. Lai, *Appl. Sci. Res.* **27**, p. 640, 1973.
Accelerating Motion of a Spheroid in Viscous Fluid, R. Y. Lai, *J. Hydraul. Div., ASCE* **99**, p. 939, 1973.
Drag on a Sphere Accelerating in a Maxwell Fluid, R. Y. Lai, *Intl. J. Engrg. Sci.* **12**, p. 645, 1974.
Accelerating Motion of a Sphere in a Maxwell Fluid, R. Y. Lai, *Appl. Sci. Res.* **30**, 1974 (in press).

183-09221-070-00

UNSTEADY FLOW TO A LARGE WELL

(*c*) Professor Robert Y. Lai, Energetics Department.
(*d*) Theoretical, applied research; M.S. thesis.
(*e*) Project deals with the unsteady flow to a large well in a leaky (or non-leaky) aquifer with special emphasis on the effect on the drawdown due to the well capacity.
(*h*) **Nonsteady Flow to a Well With Time Dependent Drawdown,** R. A. Williams, R. Y. Lai, G. M. Karadi, *Water Res. Bull.* **8**, p. 294, 1972.
Unsteady Flow to a Well in Leaky Aquifer, C. W. Su, *M.S. Thesis*, 1972.
Drawdown at Time-Dependent Flow Rate, R. Y. Lai, G. M. Karadi, R. A. Williams, *Water Res. Bull.* **9**, p. 892, 1973.
Unsteady Flow to a Large Well in a Leaky Aquifer, R. Y. Lai, C. W. Su, *J. Hydrology* **22**, p. 333, 1974.

183-09222-450-54

INTERNAL AND EXTERNAL EDGE WAVES ON AN UPWELLING FRONTAL ZONE

(*b*) National Science Foundation, IDOE-CUEA.
(*c*) Dr. David L. Cutchin, Asst. Professor of Energetics; Dr. D. B. Rao, Professor of Energetics.
(*d*) Applied theoretical research.
(*e*) Numerical solution of linearized equations of motion for a two-layered coastal sea with continental shelf topography, an upwarped pycnocline, and geostrophically balanced mean currents. Looking at the characteristics of free, trapped waves of first and second class, both internal and external. Also investigating possible dynamic instabilities.
(*g*) Final report in draft form, January 1975.

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WOODS HOLE OCEANOGRAPHIC INSTITUTION, Woods Hole, Mass. 02543. Dr. Paul M. Fye, Director.

184-07786-450-20

DYNAMIC PROCESSES IN THE DEEP SEA

(*b*) Office of Naval Research.
(*c*) Dr. N. P. Fofonoff.
(*d*) Theoretical and field investigations.
(*e*) Time series observations in the deep ocean and theoretical studies are used in the determination of the nature of dynamic processes in the sea.
(*g*) From results of recent long records from moored current meters, the dynamics of the ocean are characterized not only by steady ocean-wide flows, but also by slow variable motions with scales of hundreds of kilometers. It appears that these important eddy-like or wave-line motions are quasi-geostrophic and make up the bulk of the horizontal kinetic energy of the interior of the ocean.
(*h*) **Current Measurements in the Western Atlantic,** N. P. Fofonoff, F. Webster, *Trans. Roy. Soc. London A.* **270,** 1206, pp. 423-436, 1971.

184-09223-450-54

LABORATORY STUDIES OF BUOYANCY DRIVEN FLOWS

(*b*) National Science Foundation.
(*c*) Dr. John A. Whitehead, Jr., Department of Physical Oceanography.
(*d*) Theoretical and laboratory investigations into basic physical flow processes in the oceans and atmospheres.
(*e*) Laboratory and theoretical studies of inviscid, fully nonlinear flows in a rotating frame, and with a free upper surface are conducted. Comparison of results with oceanic flows through straits and over sills is made. Laboratory observations of Rayleigh-Benard convection in a very large Prandtl number fluid are also being taken in order to assess the stability of the bimodal convection.
(*g*) Results are generally that the sill and strait flows in nature have the same magnitude as the theoretical predictions and this gives us a handle on the gross circulation between isolated basins. In the convection experiments, the oscillations which were observed at lower Prandtl number were not observed.

184-09224-440-44

COASTAL CIRCULATION IN THE GREAT LAKES

(*b*) NOAA, Great Lakes Environmental Research Laboratory.
(*c*) Dr. Gabriel T. Csanady.
(*d*) Analysis of field data, theoretical work.
(*e*) Data collected during the International Field Year on the Great Lakes are analyzed and interpreted in terms of the concepts of fluid mechanics.
(*g*) Concentrated bands of relatively fast currents are produced by storms near the shore of large lakes within what is now known as the "coastal boundary layer." The physical properties of the coastal currents depend not only on the size and shape of the lake basin, but also significantly on the density distribution of the water and the rotation of the earth.
(*h*) **Surface Circulation of Lakes and Nearly Land-Locked Seas,** K. O. Emery, G. T. Csanady, *Proc. Nat. Acad. Sci.* **70,** 1, pp. 93-97, 1973.
Wind-Induced Barotropic Motions in Long Lakes, G. T. Csanady, *J. Phys. Oceanog.* **3,** 4, pp. 429-438, 1973.
Transverse Internal Seiches in Large Oblong Lakes and Marginal Seas, G. T. Csanady, *J. Phys. Oceanog.* **3,** 4, pp. 439-447, 1973.
Spring Thermocline Behavior in Lake Ontario During IFYGL, G. T. Csanady, *J. Phys. Oceanog.* **4,** 3, pp. 425-445, 1974.
Baroclinic Coastal Jets in Lake Ontario During IFYGL, G. T. Csanady, J. T. Scott, *J. Phys. Oceanog.* **4,** 4, pp. 524-541, 1974.

184-09225-450-52

COASTAL BOUNDARY LAYER TRANSECT

(*b*) Brookhaven National Laboratory; Energy Research and Development Administration.
(*c*) Dr. Gabriel T. Csanady.
(*d*) Theoretical and field investigations.
(*e*) Current, temperature and salinity measurements in the coastal zone (0-12 km from shore) south of Long Island are used to elucidate flow structure in the coastal boundary layer.
(*g*) The transient and the long-term circulation over continental shelves is determined by impulses received from winds and tides as well as by the density distribution of the water. An important part of the transient shelf-wide flow pattern is the coastal boundary layer where storms produce concentrated bands of currents. Time-averaged flow is, by contrast, controlled by density variations consequent upon fresh water runoff near shore.
(*h*) **Wind-Induced Baroclinic Motions at the Edge of the Continental Shelf,** G. T. Csanady, *J. Phys. Oceanog.* **3,** 3, pp. 274-279, 1973.
Barotropic Currents Over the Continental Shelf, G. T. Csanady, *J. Phys. Oceanog.* **4,** 3, pp. 357-371, 1974.

184-09226-450-20

OCEANIC VARIABILITY AND DYNAMICS

(*b*) Office of Naval Research.
(*c*) Dr. Thomas B. Sanford.
(*d*) Theoretical and field investigations.
(*e*) Most of the effort concentrates on the measurement and interpretation of motionally induced electric fields arising with water moving through the geomagnetic field. Theoretical studies and field observations are combined to define the spatial and temporal structure of flow in shallow channels and in the deep ocean.
(*g*) A better understanding of the physics of induction in broad shallow channels has been achieved. This understanding allows, under certain circumstances, the transport of a stream to be electrically monitored. In the deep ocean measurements of electric current profiles have revealed new data on the vertical structure of horizontal currents. Much of the depth-dependent variability is contributed by inertial currents.
(*h*) **Observations of Strong Current Shear in the Deep Ocean and Some Implications On Sound Rays,** T. B. Sanford, *J. Acoust. Soc. Am.* **56,** 4, pp. 1118-1121, 1974.
On the Relationship Between Transport and Motional Electric Potentials in Broad, Shallow Currents, T. B. Sanford, R. E. Flick, *J. Mar. Res.* (in press), 1975.
The Design and Performance of a Free-Fall Electromagnetic Velocity Profiler (EMVP), T. B. Sanford, R. G. Drever, J. H. Dunlap, *W.H.O.I. Ref. No. 74-46*, 123 pages, 1974 (unpublished manuscript, available from authors).

184-09227-450-20

INVESTIGATION OF THE BENTHIC BOUNDARY LAYER NEAR MYTILUS SEAMOUNT, WESTERN NORTH ATLANTIC

(*b*) Office of Naval Research.
(*c*) Dr. D. A. Johnson.
(*d*) Field investigations.
(*e*) Mytilus Seamount is located in the axis of the western boundary undercurrent of the North Atlantic, and provides a large-scale laboratory for investigating the effects of topographic obstructions upon the flow pattern and thermal stratification of deep ocean currents.
(*f*) Completed.
(*g*) The presence of the seamount within the western boundary undercurrent has modified the bottom water's flow pattern (determined by moored current meters) and thermal structure (measured by a thermometer attached to a deeply-towed instrument package). High concentrations of suspended matter are generated in a layer of isothermal ($\Theta = 1.7°C$) bottom water adjacent to the upstream flank

of the seamount, completely obscuring the seafloor to bottom photography.

(*h*) **Erosion and Sedimentation Around Mytilus Seamount, New England Continental Rise,** D. A. Johnson, P. F. Lonsdale, *Woods Hole Ocean. Inst. Tech. Rept.*, 1975.

WORCESTER POLYTECHNIC INSTITUTE, Alden Research Laboratories, Worcester, Mass. 01609. Professor Lawrence C. Neale, Director, Research Laboratories.

185-03859-700-70

METER CALIBRATIONS

(*b*) B. I. F. Industries, Providence, R. I.
(*d*) Experimental, for design.
(*e*) Calibration of open flow nozzles and flow tubes up to 48 in. in diameter. Tests performed in standard test loop and also in mock-up of particular field installations.
(*f*) Tests in progress.

185-04255-700-70

METER CALIBRATIONS

(*b*) Badger Meter Company, Milwaukee, Wis.
(*d*) Experimental; for design.
(*e*) Calibration of open flow nozzles and flow tubes from 2 in. to 48 in. in diameter in the standard test loop. In addition, tests have been performed to determine operating characteristics in a variety of field installation mock-ups including a number of pipe surface finishes.
(*f*) Tests in progress.

185-04746-700-70

METER CALIBRATIONS

(*b*) Hagan Chemicals and Controls, Inc., Pittsburgh, Pa.
(*d*) Experimental, for design.
(*e*) Calibration of a variety of sizes and designs of flow nozzles and flow nozzle assemblies.
(*f*) Tests in progress.

185-05279-700-70

METER CALIBRATIONS

(*b*) ITT General Controls, Warwick, R. I.
(*d*) Experimental, for design.
(*e*) Calibration of flow tubes in a range of sizes from 6 in. to 48 in. has been carried out. Field piping as well as standard test loop installation have been used.

185-05962-700-70

METER CALIBRATIONS

(*b*) Bailey Meter Company, Wickliffe, Ohio.
(*d*) Experimental, for design.
(*e*) Calibration of flow nozzles and flow meters in standard as well as particular metering and piping configurations for a range of sizes from 1 in. to 16 in. diameter.

185-05963-700-70

METER CALIBRATIONS

(*b*) Fischer and Porter Company.
(*d*) Experimental for design.
(*e*) Calibration of various sizes of magnetic flow tubes from 2 in. to 48 in. diameter.

185-06505-420-75

PILGRIM NUCLEAR POWER PLANT

(*b*) Bechtel Corporation, San Francisco, Calif.
(*d*) Experimental, for design.
(*e*) A 1/50 scale model of a section of Massachusetts Bay near the Boston Edison Company plant was constructed to evaluate storm protection at the proposed plant. A 4000 ft section of the shore line and the bay for an equal distance offshore was reproduced including the plant cooling water inlet and outlet structures. A 40 ft long variable speed and variable stroke wave maker was installed to generate the storm driven waves. Electronic probes were installed at critical locations to measure and record wave heights and frequencies. A variety of breakwater configurations and combinations are being tested as part of the program.
(*f*) Tests completed. Report in preparation.

185-06509-870-73

INDIAN POINT STEAM PLANT

(*b*) Consolidated Edison Company, New York.
(*d*) Experimental, for design.
(*e*) A 1/250 horizontal by 1/60 vertical scale model of a section of the Hudson River is being constructed for the Consolidated Edison Company. A 4.5 mile section of the river including the Indian Point development of units one, two and three will be studied. The model will be operated to reproduce automatically the tide cycle and will be used to study the flow patterns of the heated cooling water on return to the river. The measurements will include the flows, detailed velocities and temperature profiles over the river.
(*f*) Tests in progress.

185-06510-340-73

CORNWALL PUMPED STORAGE DEVELOPMENT

(*b*) Consolidated Edison Company.
(*d*) Experimental, for design.
(*e*) A 1/150 horizontal by 1/75 vertical scale model of a section of the Hudson River was modeled including the section at the tailrace of the plant. The studies involved determination of optimum shape of the tailrace and flow patterns and velocities for various phases of plant operation and various tide conditions. Protection of marine life in the river was also studied.
(*f*) Tests completed. Report on file.

185-06513-870-73

PEACH BOTTOM NUCLEAR STATION

(*b*) Philadelphia Electric Company.
(*d*) Experimental, for design.
(*e*) A 1/300 horizontal by 1/30 vertical scale model of the section of the Susquehanna River between Holtwood Dam and Conowingo Dam was constructed. In addition to the Holtwood and Conowingo installations the Muddy Run Pumped Storage Plant is included. At the Peach Bottom site a variety of intake and outlet structures will be studied in evaluating the heat effect on the reservoir of the Peach Bottom cooling water. Weekly cycles of plant operation at all four power stations are modeled during a test and temperature measurements at approximately 250 locations are recorded every minute of model operation. The reservoir temperature is varied from 40 °F to 85 °F and plant increase has been varied from 8 °F to 30 °F.
(*f*) Tests completed. Report in file. Model held in readiness for additional tests.

185-06514-870-73

MORGANTOWN STEAM POWER STATION

(*b*) Potomac Electric Power Company.
(*d*) Experimental, for design.
(*e*) A 1/400 horizontal by 1/40 vertical scale model of a 16-mile section of the Potomac River has been constructed. This model includes the section of the Potomac between Upper Cedar Point and Swan Point and is in the tidal range of the river. The controls are designed to automatically produce the selected tide cycle in the model and to produce river temperatures from 40 °F to 85 °F. In addition the incremental temperature is applied to the plant flow and can be varied over a range from 0 to 30 °F. The study is being conducted to evaluate the heat effect of the condenser cooling water in the river. Instrumentation has allowed approximately 150 temperature probe locations to record data each minute of operation.

(*f*) Tests completed. Report on file. Model held in readiness for additional tests.

185-08413-350-73

FIFE BROOK SPILLWAY STUDY

(*b*) New England Power Service Company.
(*d*) Experimental, for design.
(*e*) A 1 to 44.44 uniform scale model of the proposed Fife Brook Spillway, including a portion of the upstream reservoir and the river well downstream of the site was designed and constructed. Included in the model was the dam, powerhouse intake, spillway approach, spillway with gates, spillway chute, powerhouse tailrace and plunge pool. The main purpose of the study was to insure the safety of the structures and to minimize scour in the downstream area. The adequacy of the spillway chute and spillway gates was checked and a head capacity relationship over a range of gate openings was developed.
(*f*) Tests completed. Report on file. Model held in readiness for further tests.

185-08416-340-73

McGUIRE INTAKE STUDY

(*b*) Duke Power Company.
(*d*) Experimental, for design.
(*e*) A 1/15 scale model of the intake structure for cooling water at the McGuire Nuclear Power Station of the Duke Power Company on Lake Norman. The model includes a section of the reservoir upstream on the intake and a passive pump bell and barrel on the downstream side of the modeled structure. The design incorporates separate water supply as a manifold and discharge pipe set behind the curtain wall in each bay to supplement water taken directly from the reservoir. This supply is drawn from the deep portions of the reservoir at the upstream face of the nearby Cowans Ford dam. In addition to investigating flow patterns during normal operation it is intended to study the flow with various combinations of flow from the reservoir and manifold.
(*f*) Tests completed. Report on file.

185-08417-630-73

PUMP TEST PROGRAM

(*b*) Foster-Wheeler Company.
(*d*) Experimental, for design.
(*e*) In cooperation with the Foster-Wheeler Company, several pump models are being evaluated as a part of a development and background research project. This program is being carried out on the 100-HP variable speed test rig. The work is being conducted in close cooperation with the sponsor so as to have the program reflect the latest data and up-to-date designs from Foster-Wheeler. The details of the 100-HP test rig and the associated equipment are available in the Alden Research Laboratories' Brochure on Fluid Machinery Testing.
(*f*) Test completed. Report on file. Model held in readiness for further tests.

185-08420-870-73

LAKE NORMAN MODEL STUDY

(*b*) Duke Power Company.
(*d*) Experimental, for design.
(*e*) Lake Norman, on the Catawba River in North Carolina, was formed by construction of the Cowans Ford Dam completed in 1963. Lake Norman is a reservoir of approximately 32,500 acres with a volume of approximately 1,000,000 acre feet. Cowans Ford was built as a multipurpose project, including hydro power generation, water supply, flood control, recreation and to serve as a source of condenser cooling for thermal power generating stations. There are a number of thermal station sites on the lake, one of which is Marshall Steam Station, a fossil fuel plant, completed in 1970, having a capacity of 2137 megawatts with four units. The William B. McGuire Nuclear Station under construction, is located near the Cowans Ford Dam. McGuire has two units of 1150 megawatts each for a total of 2300 megawatts. Two other sites will probably be developed in the 1980's. The model of Lake Norman is located in a building 182 feet long by 90 feet wide and is constructed to a scale ratio of 1:600 horizontally and 1:60 vertically. The corresponding velocity ratio is 1:7.75 and the flow ratio is 1:278,855. The condenser cooling water temperature rise is simulated by heating water with electric element heaters. A Model 300 Data-logger acquisition system scans and records 300 individual temperature sensing thermistor points in the model. Heat patterns on the surface and in depth are then obtained in the lake.
(*f*) Tests in progress.

185-08421-340-73

PARR HYDRO-ELECTRIC PROJECT

(*b*) South Carolina Electric and Gas Company.
(*d*) Experimental, for design.
(*e*) The Broad River is dammed at Parr Shoals to form Parr Reservoir and a fossil fuel steam plant of 70,000 kW and a hydro-electric plant of 14,880 kW are located at or near the dam. Under the proposed project the dam would be elevated to increase the capacity of the Parr Reservoir which would also serve as the lower reservoir for the pumped-storage scheme. The upper reservoir will be formed by damming Frees Creek with a main dam 5000 feet in length and two extensive saddle dams each approximately 3000 feet in length. The total impoundment would contain approximately 400,000 acre-feet (1.3 billion gallons) of water. The elevation difference between the upper reservoir and the lower reservoir would be 157 feet with both reservoirs filled to capacity. The proposed pumped-storage plant utilizing this head would have a total installed capacity of 480 MW. The upper reservoir is being studied as a possible site for a nuclear plant of at least two units. Studies are currently in progress to determine the size and location of these units. The model of the two reservoirs and associated power plants is situated in a building 140 feet long by 50 feet wide and is constructed to a scale of 1 to 50 vertical and 1 to 500 horizontal. Broad River flows, steam and nuclear condenser flows and pumped storage flows are properly modeled using calibrated metering sections in each of the respective plants. In the case of the fossil fuel and the nuclear plant the temperature rise across the condensers is also modeled. Heat patterns at the surface and in depth are obtained on both the upper and lower reservoir by use of thermocouples or thermistors along with suitable instrumentation.
(*f*) Tests in progress.

185-08424-870-73

YORKTOWN STEAM POWER STATION

(*b*) Virginia Electric Power Company.
(*d*) Experimental, for design.
(*e*) A distorted model (1/60 and 1/465) of the tidal portion of the York River including a section of Chesapeake Bay at the mouth has been constructed for the Virginia Electric Power Company. The existing two units have been modeled and tested with the present intake canal and shoreline surface discharge for the condenser cooling water. The tidal flow and stage are produced automatically at the bay end of the model. Temperature data is taken with thermocouple sensors with a data logger on punched tape. After confirming the model data with the existing units by means of data from the field the third unit with a different outlet design (jet discharge – offshore) was installed and tested. In addition a new design of outlet for Units 1 and 2 (similar to Unit 3) was tested. The requirement by the regulatory agency requires a temperature rise no greater than 1.5 degrees F extending fully across the estuary.
(*f*) Tests completed. Report on file.

185-08425-350-75

TARBELA DAM PROJECT

(*b*) Tippets, Abbett, McCarthy and Stratton.
(*d*) Experimental, for design.
(*e*) A 1/80 scale model of both the Tarbela Spillways (Service and Auxiliary) is being tested for TAMS who are the designers for the Water and Power Authority of Pakistan. The model includes sections of reservoir upstream of each spillway, the discharge chutes and aprons and approximately one-half mile of the Dal Darra or channel downstream. The purpose of the study is to investigate the scour of the poor rock downstream of the spillways and to review experimentally any modifications necessary to insure the safety of the spillways. The data has been developed using miniature current meters and Pitot tubes for the velocities while plan view photographs have been the main source of scour data.
(*f*) Tests completed. Report on file.

185-08426-700-70

WESTINGHOUSE L.E. SONIC FLOW METER

(*b*) Westinghouse Electric Corporation.
(*d*) Experimental, for design.
(*e*) A 12 in., 24 in. and 48 in. diameter ultrasonic flow meter was calibrated in the 100,000 pound weigh tank loop. The upstream flow distribution was varied and measured in order to evaluate its effect on performance.
(*f*) Tests in progress.

185-08427-870-75

ROSETON STEAM POWER STATION

(*b*) Quirk, Lawler and Matusky.
(*d*) Experimental, for design.
(*e*) A 1/90 scale model of a two-mile section of the Hudson River including the existing Danskammer Plant and the proposed Roseton Plant of the Central Hudson Power Company has been constructed in cooperation with Quirk, Lawler and Matusky. The model is designed to reproduce the tidal effects at this section automatically and to reproduce the flows and temperature rises of both plants. The study is to determine the patterns of increased temperature in the Hudson River for a range of operating conditions on each plant and with a variety of intake and outlet structures. The model is being instrumented with thermocouples to give the required temperature sensing coverage.
(*f*) Tests completed. Report on file.

185-08429-340-75

DAVIS PUMPED STORAGE DEVELOPMENT

(*b*) Ebasco Services, Inc.
(*d*) Experimental, for design.
(*e*) A 1/50 scale model of a section of the Upper Reservoir including the intake/outlet is being constructed for Ebasco Services, Inc., who are the designers acting for the Allegheny Power Service Corporation. The model is approximately 60 feet by 80 feet in plan and includes approximately 50 percent of the upper reservoir. The studies are being carried out to optimize flow entering or leaving the structure and to eliminate undesirable effects such as vortex formation non-uniform flow. The model is about 50 percent completed and should be completed within the month and testing will then proceed for a period of several months. The construction is a fiberglass shell representing the topography and the entire model is constructed over an existing model which is being preserved.
(*f*) Tests completed. Report on file.

185-09228-340-73

MARTINS CREEK STEAM POWER STATION

(*b*) Pennsylvania Power and Light Company, Allentown, Pa.
(*d*) Experimental, for design.
(*e*) A 1/25 scale model of a two-mile section of the Delaware River was constructed and tested for the PPL Co. The model included the present cooling water intake and outlet for the existing units No. 1 and No. 2. The model included the necessary apparatus to reproduce the temperature increase and correct model plant flow as well as instrumentation to continuously survey the resulting temperature pattern in the river. As a result of the study a multiple port manifold for warm water release was developed and located. This manifold was intended to replace the existing surface-shoreline release system.
(*f*) Tests completed. Report on file.

185-09229-210-13

PARK RIVER CONDUIT

(*b*) United States Army – Corps of Engineers.
(*d*) Experimental, for design.
(*e*) A 1/25 scale model of the East and West Branch of the Park River Conduit at Hartford, Conn., was constructed to include the junction and a section of the combined conduit leading out of the junction. Flow in the junction and into a circular tunnel to serve as a bypass was studied.
(*f*) Tests completed. Report on file.

185-09230-340-75

HANFORD NUCLEAR FACILITY

(*b*) Burns and Roe, New York, N. Y.
(*d*) Experimental, for design.
(*e*) A 1/12 scale model of the three pump screenwell was constructed and tested in order to evaluate the wet pit type pump performance on a variety pump operating circumstances and a number of inlet flow conditions.
(*f*) Tests completed. Report on file.

185-09231-700-70

BLUE PLAINS TREATMENT PLANT

(*b*) Westinghouse Corp., Annapolis, Md.
(*d*) Experimental, for design.
(*e*) The flow monitoring sections for the new treatment plant at Washington, D. C. involve the Leading Edge Ultra Sonic Flow Measurement System. Flow tests in 48 in. diameter sections, 18 in. x 18 in. duct and 36 in. x 36 in. duct have been conducted to guide design and evaluate performance.
(*f*) Test in progress.

185-09232-340-75

NINE MILE POINT – INTAKE STUDIES

(*b*) Stone and Webster Engineering Corp., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A full scale model of one section of an offshore octagonal intake was installed in an 80 ft x 60 ft flume designed to represent an offshore section of lake at the site of the Niagara Mohawk Nuclear Plant. The flow capacity of the facility is 135 cubic feet per second and provision is made for introducing and retrieving fish from the facility.
(*f*) Tests in progress.

185-09233-340-75

PORTLAND STEAM POWER PLANT

(*b*) Gilbert Associates, Reading, Pa.
(*d*) Experimental, for design.
(*e*) A 1/35 scale model of an 1800 ft section of the Delaware River was constructed including the site of the Portland Plant of the Metropolitan Edison Company. The study involved development of necessary modifications to the cooling water discharge structure to accomplish required changes in the warm water flow patterns in the river.
(*f*) Tests completed. Report in preparation.

185-09234-630-75

NINE MILE POINT – JET PUMP STUDIES

(*b*) Stone and Webster Engineering Corp., Boston, Mass.

(*d*) Experimental, for design.
(*e*) A series of tests were conducted to evaluate the possible use of a jet pump for handling and transporting fish. Two core jet pumps were tested. One was a 24 in. diameter pipe and the other a 4 in. diameter pipe. In addition a 4 in. diameter pipe peripheral jet pump was also tested. In addition to hydrodynamic tests to evaluate pump characteristics, all pumps were operated with fish to determine handling characteristics.
(*f*) Tests in progress.

185-09235-850-75

NINE MILE POINT – INTAKE STUDIES

(*b*) Stone and Webster Engineering Corp., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A 1:9 scale model of a submerged intake for the Niagara Mohawk Nuclear Plant was constructed to develop and study a number of louver combinations designed to guide fish to a return loop. Velocity patterns and pressure drops for a number of louver designs and arrangements were documented.
(*f*) Tests in progress.

185-09236-850-75

NINE MILE POINT – FISH TRANSPORT STUDIES

(*b*) Stone and Webster Engineering Corp., Boston, Mass.
(*d*) Experimental, for design.
(*e*) The set-up consists of a 10 in. diameter pipeline approximately 150 ft long with seven clear plastic sections including two elbows. A supply tank with a possible head of 12 ft and a discharge tank were installed to complete the set-up. Fish were introduced and observed at the various transparent sections for a variety of flow rates.
(*f*) Tests in progress.

185-09237-850-75

NINE MILE POINT – FISH PRESSURE STUDIES

(*b*) Stone and Webster Engineering Corp., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A pressure vessel approximately 12 in. x 12 in. x 18 in. was fabricated of steel with a clear side for observation purposes. Pressure connections and an introduction port were provided. Fish could be introduced and pressure of varying amounts could be made during the tests.
(*f*) Tests in progress.

185-09238-340-75

MILLSTONE CONDENSER WATER BOX

(*b*) Stone and Webster Engineering Corp., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A 1/8 scale model of the water box including associated upstream pipe and condenser tube sheet was constructed for the Millstone Nuclear Power Station of the Connecticut Yankee Company. The tests were aimed at determining and possibly improving the flow patterns in the water box and through the condenser tubes. The model was constructed largely of clear plastic in order to allow visual and photographic observation.
(*f*) Tests completed. Report on file.

185-09239-850-75

NINE MILE POINT – SCREENWELL STUDIES

(*b*) Stone and Webster Engineering Corp., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A series of tests were conducted in a 3 ft x 3 ft glass sided flume to study a variety of screens louvers and bar screens as used for guidance devices for fish. A number of combinations of angles, spacing, bypass flow arrangements were tested both for hydrodynamic characteristics and behavioral characteristics using fish.
(*f*) Tests in progress.

185-09240-850-73

TURNERS FALLS HYDROELECTRIC STATION – FISH LADDER

(*b*) Northeast Utilities, Hartford, Conn.
(*d*) Experimental, for design.
(*e*) A 1/16 scale model of the upper portion of the fish ladder for the Turners Falls dam was constructed in order to develop flow patterns and velocities in the various stages for a range of upper reservoir levels. In addition, the flow from the attraction water distribution box was also studied.

185-09241-340-

SEABROOK NUCLEAR POWER STATION

(*b*) United Engineers, Inc., Philadelphia, Pa.
(*d*) Experimental, for design.
(*e*) A 1/115 scale model of a two mile square section of Atlantic Ocean including the offshore siting of structures for the Seabrook Nuclear Power Station of Public Service of New Hampshire and Yankee Atomic was constructed. Included in the model were the submerged intake structure and the manifold discharge structure. The condenser cooling water flow was withdrawn through the intake heated to the correct temperature and discharged through the manifold. Near field temperature patterns were recorded for a variety of operating and ocean current conditions.
(*f*) Tests in progress.

185-09242-350-73

TURNERS FALLS HYDROELECTRIC STATION – FISH LADDER

(*b*) Northeast Utilities, Hartford, Conn.
(*d*) Experimental, for design.
(*e*) A 1/9 scale model of a section of the Connecticut River at Turners Falls including a section of the dam, bascule gates and left bank was constructed. Included at the left bank was the entrance and lower portions of a fish ladder designed to permit fish passage over the dam. Studies were directed at determining the velocity patterns from below the rapids to the area of the entrance and to investigate necessary changes to produce a velocity pattern acceptable to migrating fish.
(*f*) Tests in progress.

185-09243-340-73

SEABROOK NUCLEAR POWER STATION

(*b*) Yankee Atomic Electric Co., Westborough, Mass.
(*d*) Experimental, for design.
(*e*) A 1/12 scale model of the screenhouse associated with the Seabrook Nuclear Power Station of Public Service Company of New Hampshire. The model includes approach piping from the offshore intake, forebay screens, pump bells and piping corresponding to the wet pump barrels. Flow is induced in each of the six model pump bells by syphon. Observations include velocity measurements with miniature current meter, visual and photographic note of tufts and flags in appropriate locations. Windows in screenhouse walls and floor permit viewing from sides, back and floor beneath model.
(*f*) Tests in progress.

185-09244-870-75

SHOCKOE CREEK BASIN

(*b*) Hayes, Seay, Mattern and Mattern, Roanoke, Va.
(*d*) Experimental, for design.
(*e*) A 1/18 scale model of two trunk sewers in the City of Richmond, Va., was constructed to include the present junction of the two sewers before discharge into the James River. Initial studies involved development of a flow measurement system for each conduit. Subsequent studies involve performance of a new control and diversion structure to regulate flow to a new retention basin and to the river.
(*f*) Tests in progress.

185-09245-340-75

CORNWALL PUMPED STORAGE DEVELOPMENT

(*b*) Charles T. Main, Inc., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A 1/80 uniform scale model of the upper reservoir of the Pumped Storage Plant of Consolidated Edison Company of New York was constructed including the associated intake structure and necessary excavation. Testing involved a variety of flow rates in both pumping and generating operating modes with special attention to velocity patterns and possible vortex formation at or near the intake.
(*f*) Tests completed. Report on file. Model held in readiness for additional tests.

185-09246-850-73

FLUME FOR FISH GUIDANCE STUDIES

(*b*) Consolidated Edison Company of New York.
(*d*) Experimental, for design.
(*e*) A recirculating flume of steel with clear plastic viewing panels has been constructed to study the operation and effectiveness of various devices such as screens, louvers, curtains and equivalent types. The flow capacity is in excess of 100 cfs and the test section is a basic 6 ft by 6 ft in cross section. Fish of various sizes and species are studied under a variety of velocity, temperature and other conditions.
(*f*) Tests in progress.

185-09247-340-73

D. C. COOK NUCLEAR POWER PLANT

(*b*) American Electric Power Company, New York, N. Y.
(*d*) Experimental, for design.
(*e*) A 1/75 model of a section of the eastern shore of Lake Michigan including the pertinent intake and outlet structures for the D. C. Cook Plant was constructed and tested. The test program concentrated on the performance of the offshore structures as related to temperature patterns produced under a variety of operating conditions. The data retrieval system developed for the model produced a surface temperature map in the plant area as well as selected temperature profiles. Velocity patterns as related to such other aspects as bottom scour and navigation were also determined.
(*f*) Tests completed. Report on file. Model held in readiness for further tests.

185-09248-340-73

D. C. COOK NUCLEAR POWER PLANT

(*b*) American Electric Power Company, New York, N. Y.
(*d*) Experimental, for design.
(*e*) A 1/40 scale model of the submerged intake structure for the D. C. Cook Power Station was installed and tested for wave force. In connection with the study a 4 ft x 4 ft x 60 ft long glass sided steel flume was constructed and equipped with a variable speed, variable stroke paddle-type wave maker. The model intake structure was instrumented with a number of pressure transducers and accelerometers to document pressures and forces on the intake due to the operation and wave action.
(*f*) Tests completed. Report on file.

185-09249-350-75

BASCULE GATE STUDY

(*b*) Dravo Company, Neville Island, Pittsburgh, Pa.
(*d*) Experimental, for design.
(*e*) A 1/15 scale model of two bascule gates and the associated upstream and downstream structural and pertinent river components of the Parr Frees Power Station of the South Carolina Electric and Gas Company were modeled. Tests included calibration of the gates in various positions.
(*f*) Tests completed. Report on file.

185-09250-350-75

FORTUNA SPILLWAY AND DIVERSION STUDY

(*b*) Charles T. Main, Inc., Boston, Mass.
(*d*) Experimental, for design.
(*e*) A 1/25 uniform scale model of the approach and downstream areas including the dam, spillway and diversion tunnel at the Fortuna Hydroelectric Power Development of the Panama Electric Company was built and tested. The test program includes study of the diversion tunnel performance, the spillway operation, and capacity and effects of possible overtopping of the dam during extreme floods.
(*f*) Tests in progress.

185-09251-700-70

METER CALIBRATIONS

(*b*) Brooks Instruments, Inc., Hatfield, Pa.
(*d*) Experimental, for design.
(*e*) Calibration of various sizes of magnetic flow tubes from 30 in. to 54 in. diameter.

185-09252-210-70

VALVE FLOW TESTS

(*b*) ITT General Controls, Warwick, R. I.
(*d*) Experimental, for design.
(*e*) Flow tests and flow visualization studies on a 24 in. diameter ball-control valve.
(*f*) Tests in progress.

185-09253-210-70

VALVE FLOW TESTS

(*b*) Atwood and Morrill Co., Salem, Mass.
(*d*) Experimental, for design.
(*e*) Flow tests (transient and steady state) on a 24 in. diameter plug-check valve.
(*f*) Tests completed.

185-09254-210-70

VALVE FLOW TESTS

(*b*) ITT General Controls, Warwick, R. I.
(*d*) Experimental, for design.
(*e*) Flow tests on a butterfly valve in forward and reverse direction to evaluate pressure drop and torque characteristics for a full range of disc angles.
(*f*) Tests in progress.

185-09255-210-70

VALVE FLOW TESTS

(*b*) Kennedy Valve Co., Elmira, N. Y.
(*d*) Experimental, for design.
(*e*) Flow tests on 20 in. and 24 in. diameter butterfly valves were conducted for both forward and reverse direction. Measurements of pressure drop and torque were made for a variety of flows and disc angles.
(*f*) Tests in progress.

185-09256-140-00

HEAT TRANSFER STUDY

(*d*) Basic research.
(*e*) Floating, shallow freeboard pans were fully instrumented and installed on long-term basis in natural reservoir. Heat transfer characteristics and related information were developed experimentally to assess and compare usually accepted techniques for analytical evaluations.
(*f*) Program continuing.

185-09257-700-70

METER CALIBRATIONS

(*b*) Ocean Research Equipment, Falmouth, Mass.
(*d*) Experimental, for design.

(*e*) Calibration of 24 in. and 48 in. ultrasonic type flowmeters were calibrated with a variety of upstream piping configurations in order to evaluate upstream piping effects.
(*f*) Tests completed.

185-09258-700-70

METER CALIBRATIONS

(*b*) Peerless Nuclear Corporation, Stamford, Conn.
(*d*) Experimental, for design.
(*e*) Calibrations of numbers of flow nozzles with associated piping were carried out for pipe sizes of 5 in. and 10 in. diameter.

185-09259-700-70

METER CALIBRATIONS

(*b*) Tech Tube Corporation, Houston, Tex.
(*d*) Experimental, for design.
(*e*) Calibration of various sizes of venturi tubes from 10 in. to 36 in. diameter.

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UNIVERSITY OF WYOMING, College of Engineering, Department of Mechanical Engineering, University Station, Box 3295, Laramie, Wyo. 82070. Dr. William R. Lindberg.

186-09267-020-00

DIFFUSION AND LAGRANGIAN STATISTICS IN TURBULENT FLOWS

(*d*) Theoretical; numerical.
(*e*) Numerical simulations of turbulent flows with correct second-order statistical structure are formed. Particles of various sizes and densities are then numerically tracked through this field and the relevant statistical measures are determined. To date, isotropic flows and channel flows have been simulated.
(*h*) **Simulation of Three-Dimensional Turbulence With Given Second-Order Statistical Structure,** *Quart. J. Roy. Met. Soc.* **100,** pp. 608-623, Oct. 1974.

186-09268-060-00

TURBULENCE IN STABLY STRATIFIED FLOWS

(*d*) Experimental; theoretical.
(*e*) Investigation of turbulence in the following stably stratified systems' grid-generated box turbulence; grid-generated channel flow; turbulent Ekman layers.

186-09269-020-06

THE TURBULENT DIFFUSION OF BLOWN SNOW

(*b*) U. S. Forest Service, Department of Agriculture.
(*c*) Dr. J. E. Nydahl, Dr. W. R. Lindberg.
(*d*) Theoretical; experimental.
(*e*) A predictive model for determining the sublimation rate of blowing snow is being developed. Turbulence effects have been incorporated. Existing data on transport distances and particle life-times are adequately predicted. The transient effect on sublimation rates is in the process of being studied.
(*h*) **Sublimation of Snow in a Turbulent Atmosphere,** L. W. Lee, *Ph.D. Thesis*, Univ. Wyoming, 1975.

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YALE UNIVERSITY, Department of Geology and Geophysics, New Haven, Conn. 06520. Professor Robert B. Gordon.

187-09270-410-10

SEDIMENTARY PROCESSES IN A HIGH ENERGY, COASTAL ENVIRONMENT

(*b*) U. S. Army Corps of Engineers.
(*d*) Field research and analysis on basic processes of sediment transport through, and deposition in, coastal zone areas characterized by strong tidal streams.
(*e*) Immediate objectives include determination of the mass balance for sedimentary materials in Long Island Sound; construction of a quantitative model of the sediment transport and deposition processes in the Sound; and quantitative analysis of the physical processes involved in the disposal of dredged materials in coastal waters.
(*g*) The coefficients of the transport model have been determined and used to predict a boundary sand flux in Long Island Sound. Measurements confirm the predicted flux. Erosional and consolidation processes at the New Haven spoil ground are under observation; little loss of recently dumped spoil from the disposal site is detected.
(*h*) **Dispersion of Dredge Spoil in Near-shore Waters,** R. B. Gordon, *Estuarine and Coastal Mar. Sci.* **2,** pp. 349-358, 1974.

187-09271-450-10

HYDRAULIC REGIME IN LONG ISLAND SOUND

(*b*) U. S. Army Corps of Engineers.
(*d*) Field observations and analysis of water movements in a large coastal estuary.
(*e*) Identify the steady, periodic and fluctuating components of currents near the bottom of Long Island Sound. Current meter records are analyzed for net flow, tidal constituents and turbulence intensity and these are related to sources of driving energy. The effects of storms and of river runoff on water movements are being determined.
(*g*) The net circulation in the central Sound, and its seasonal variation, has been determined.
(*h*) **Circulation in Central Long Island Sound,** R. B. Gordon, C. C. Pilbeam, *J. Geophys. Res.* **80, p. 414, 1975.**

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PROJECT REPORTS FROM U. S. GOVERNMENT LABORATORIES

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

NORTH CENTRAL REGION, 2000 West Pioneer Parkway, Peoria, Ill. 61614. E. R. Glover, Deputy Administrator.

300-0185W-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM LOESS AND CLAYPAN WATERSHEDS IN MISSOURI AND IOWA

See Water Resources Research Catalog **9**, 2.0671.

300-0186W-220-00

RATES AND PROCESSES OF RESERVOIR SEDIMENTATION IN THE CORN BELT

See Water Resources Research Catalog **9**, 2.0670.

300-0188W-810-00

SEDIMENT YIELDS FROM AGRICULTURAL WATERSHEDS IN THE CORN BELT

See Water Resources Research Catalog **9**, 2.0672.

300-0189W-810-00

MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF, EROSION, AND TILTH-CLAYPAN SOILS

See Water Resources Research Catalog **9**, 4.0133.

300-0192W-810-00

THE MOVEMENT AND YIELD OF NUTRIENTS FROM AGRICULTURAL WATERSHEDS

See Water Resources Research Catalog **9**, 5.0934.

300-0342W-860-00

RELATION OF AGRICULTURAL PRACTICES TO WATER QUALITY IN THE NORTH APPALACHIAN REGION

See Water Resources Research Catalog **9**, 2.0818.

300-0343W-840-00

IRRIGATION METHODS, WATER AND FERTILITY REQUIREMENTS OF SOILS AND CROPS IN MINNESOTA

See Water Resources Research Catalog **9**, 3.0213.

300-0344W-860-00

RELATION OF AGRICULTURAL PRACTICES AND NATURAL VEGETATION TO NUTRIENT CONTENT OF WATERS

See Water Resources Research Catalog **9**, 5.0903.

300-0345W-830-00

CONTROL OF WATER EROSION WITH ORGANIC MULCHES IN NEBRASKA

See Water Resources Research Catalog **9**, 2.0703.

300-0346W-830-00

WATER EROSION PROCESSES IN RELATION TO WINDS IN THE GREAT PLAINS

See Water Resources Research Catalog **9**, 2.0545.

300-0347W-870-00

USE OF SEWAGE SLUDGE ON AGRICULTURAL LANDS

See Water Resources Research Catalog **9**, 5.0910.

300-01723-350-00

HYDRAULICS OF WATER CONTROL STRUCTURES AND CHANNELS

See St. Anthony Falls Hydraulic Lab. Project Nos. 00111, 01168, 07677, and 08993.

(*b*) Cooperative with the Minnesota Agric. Expmt. Station; and the St. Anthony Falls Hydraulic Laboratory.

(*c*) Mr. Fred W. Blaisdell, Research Leader, St. Anthony Falls Hydraulic Lab., 3rd Ave. S. E. at Mississippi River, Minneapolis, Minn. 55414.

(*d*) Experimental; applied research for development and design.

(*e*) Research dealing with the design, construction, and testing of structures for conserving and controlling soil and water are carried out. Cooperation with and coordination of the tests at the Stillwater, Oklahoma, Water Conservation Structures Laboratory is maintained. Model tests of the Marsh Creek Dam principal spillway, Contra Costa County, California, have been completed. Present research is a generalized investigation of the scour at cantilevered pipe outlets. The objective is to develop criteria for the design of plunge pool energy dissipators for any pipe size, discharge, and bed material.

(*h*) **Hydraulics of Closed Conduit Spillways, Part XII: The Two-Way Drop Inlet With a Flat Bottom,** C. A. Donnelly, G. G. Hebaus, F. W. Blaisdell, Agri. Res. Service, U. S. Dept. of Agric., *ARS-NC-14*, 66 pages, Sept. 1974. Copies of the report may be obtained from the Agricultural Research Service, St. Anthony Falls Hydraulic Laboratory, at the address given in (c) above.

The following reports and papers are in various stages of completion: **Hydraulics of Closed Conduit Spillways, Part XIII. The Hood Drop Inlet; Part XIV. Antivortex Walls for Drop Inlets; Part XV. Low-Stage Inlet for the Two-Way Drop Inlet; Part XVI. Elbows and Transitions for the Two-Way Drop Inlet; Part XVII. The Two-Way Drop Inlet with a Semicylindrical Bottom.**

Hydraulic Model Investigation of Marsh Creek Dam Principal Spillway, Contra Costa County, California; Theory of Flow in Long Siphons; The Hood Inlet Self-Regulating Siphon Spillway; The Two-Way Drop Inlet Self-Regulating Siphon Spillway.

300-04275-830-00

MECHANICS AND CONTROL OF EROSION BY WATER

(*b*) Cooperative with Purdue University Agricultural Expmt. Station.

(*c*) W. H. Wischmeier, Agric. Engrg. Bldg., Purdue Univ., Lafayette, Ind. 47907.

(*d*) Experimental, theoretical, and field investigations; basic, applied and developmental research.

(*e*) Field, laboratory, and analytical studies of soil detachment and transport by rainfall and runoff; effects of plant covers, crop residues, tillage methods, and soil treatments on erosion and runoff; hydraulics of eroding runoff and rainfall; and mathematical models of the soil erosion process as a basis for improved methods of erosion prediction and erosion control.

(*g*) Basic erosion modeling concepts were combined with the Universal Soil Loss Equation to derive a formula that predicts the variations in soil detachment along field or construction-site slopes that are nonuniform in gradient or soil type. A graphical procedure developed from the formula enables technicians to evaluate the soil loss equation's topographic factor and effects of changes in soil type for nonuniform slopes. Various versions of "conservation tillage" for corn showed wide differences in erosion-control effectiveness when tested under identical artificial rains. The relations of soil-loss reductions to various measurable surface conditions induced by the practices were derived. These can be numerically combined to predict the effectiveness of particular practices or implements in specific situations. Soil-loss predictions for single-storm events were significantly improved by including a runoff erosivity term and separate terms for rill and interrill erosion in the prediction equation. Such improvements were obtained when a preliminary erosion equation of this type was developed from modeling principles and applied to conditions of two midwestern watersheds. Although velocity, depth, and shear stress of flow in a rill vary greatly from location to location, the variations closely follow a normal distribution. Measurements of flow over a full size replica of a rill showed that mean velocity and shear stress for a 10-foot length of rill can be described by equations similar to those used to describe stream flow.

(*h*) **Nitrogen and Phosphorus Composition of Runoff As Affected By Tillage Method,** M. J. M. Romkens, D. W. Nelson, J. V. Mannering, *J. Environ. Qual.* **2,** 2, pp. 292-295, 1973.

Chemical Weed Controls Affect Runoff, Erosion, and Corn Yields, F. D. Whitaker, H. G. Heinemann, W. H. Wischmeier, *J. Soil and Water Conserv.* **28,** 4, pp. 174-176, 1973.

Conservation Tillage to Control Water Erosion, W. H. Wischmeier, *Proc. Natl. Conserv. Tillage Conf.*, Des Moines, Iowa, SCSA, pp. 133-141, 1973.

Soil Erodibility on Construction Areas, W. H. Wischmeier, L. D. Meyer, HRB, Natl. Academy Sci., *Spec. Rept. 135*, pp. 133-141, 1974.

300-09272-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE NORTH APPALACHIAN REGION

(*b*) Cooperative with the Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

(*c*) W. R. Hamon, Acting Location Leader, North Appalachian Watershed Research Center, Coshocton, Ohio 43812.

(*d*) Experimental, theoretical, and field investigations; basic and applied research.

(*e*) Watershed studies to describe infiltration, percolation, groundwater, and overland and channel flow components of the hydrologic cycle with a mathematical model and to relate these components to definable physical parameters; predict watershed flow, including transport of water, sediment and agricultural chemicals and wastes; describe areal precipitation characteristics; and relate ET losses to soil, vegetation, and meteorological factors.

(*g*) A modified combination equation for predicting evapotranspiration was developed and tested. Results indicate that the equation can be used to estimate actual daily ET with confidence in the humid Northeast from climatic data. The USAHL-73 Watershed Model was applied independently by two scientists to a 43.6 acre forested watershed specifying a three- and a four-zone model. Differences in total runoff between the two adaptations varied from less than one percent in a wet year to 40 percent in a dry year.

(*h*) **Effect of Long-Term Management on Physical and Chemical Properties of the Coshocton Watershed Soils,** W. M. Edwards, J. L. McGuinness, D. M. Van Doren, Jr., G. F. Hall, G. E. Kelley, *Proc. Soil Sci. Soc. Amer.* **37,** 6, pp. 927-930, 1973.

Scheduling Irrigations Using a Programmable Calculator, D. C. Kincaid, D. F. Heerman, *Technical Handbook*, *ARS-NC-12*, Feb. 1974.

300-09273-870-00

FIELD DETERMINATION OF NUTRIENTS AND SEDIMENTS FROM NON-POINT SOURCES

(*b*) Cooperative with the Minnesota Agricultural Experiment Station, St. Paul, Minn. 55108.

(*c*) R. A. Young and C. A. Onstad, Agric. Engineers, North Central Soil Conservation Research Center, Morris, Minn. 56267.

(*d*) Experimental, theoretical, and field investigations; basic and applied research.

(*e*) Assess the impact of man on nutrient enrichment of lakes and streams. Develop hydrologic and nutrient budget for agricultural and non-agricultural watersheds. Relate water quality and sediment yield to watershed land use practices. Model agricultural chemical transport.

(*g*) Agricultural and non-agricultural non-urban watersheds in west central and northern Minnesota were instrumented. Data collection began in 1974. Data are being used to test agricultural chemical transport models, develop water and nutrient budgets for the watersheds, and to relate water quality and sediment yields to land use practices.

300-09274-840-00

AGRICULTURAL DRAINAGE SYSTEMS DESIGN AND INSTALLATION

(*b*) Cooperative with the Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

(*c*) N. R. Fausey, Soil Scientist, North Appalachian Watershed Research Center, Coshocton, Ohio 43812.

(*d*) Experimental, theoretical, and field investigations; basic and applied research.

(*e*) Describe the hydraulics of water flow into subsurface drains with mathematical, numerical, analog, and experimental techniques. Identify adverse drainage conditions and correlate with soil properties and land physiographic features to optimize farm operations. Develop new drain materials and installation techniques for agricultural lands.

(*g*) Numerical techniques were used to describe water flow to shallow drainage systems (approximately 18 inches deep). The analogous resistance-capacitance series circuit equation adequately defined the transient part of the infiltration capacity curve obtained on three soils with a rainfall simulator. A numerical one-dimensional soil water flow model was developed. Implicit finite difference techniques were used to solve the general soil water flow equation for saturated-unsaturated conditions.

(*h*) **Drainage and Timeliness of Farming Operations,** R. C. Reeve, N. R. Fausey, in *Drainage for Agriculture*, *Amer. Soc. Agron., Monog. No. 17*, Chapter 4, pp. 55-66, 1974.

Comparison of Drainage Methods in a Heavy-Textured Soil, G. O. Schwab, N. R. Fausey, D. W. Michiener, *Amer. Soc. Agr. Engrg. Trans.* **17,** 3, pp. 424-425, 1974.

Draintube Plows: Their Operation and Laser Grade Control, J. L. Fouss, N. R. Fausey, R. C. Reeve, *Amer. Soc. Agr. Engin., Natl. Drain. Symp. Proc.*, 1972.

300-09275-870-00

ASSESSMENT AND CONTROL OF POLLUTION OF SURFACE AND GROUND WATERS BY FERTILIZERS

(*b*) Cooperative with the Nebraska Agricultural Experiment Station, Lincoln, Nebr. 68503.

(*c*) G. E. Schuman, L. N. Mielke, and T. M. McCalla, USDA-ARS, 145 Keim Hall, Lincoln, Nebr. 68503.

(*d*) Experimental, theoretical, and field investigations on watershed sized units; basic and applied research.

(*e*) To determine the discharge of agricultural fertilizers, pesticides, herbicides, and biologicals in surface runoff and sediment and to follow with time the movement of nitrogen through the soil profile and into the groundwater. Evaluate the effects of irrigation practices on the infiltration and deep percolation of nitrogen beyond the root zone.

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U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

NORTHEASTERN REGION, Room 333, B-003, Agricultural Research Center, West Beltsville, Md. 20705. Dr. S. C. King, Deputy Administrator.

301-04820-810-00

HYDRODYNAMICS OF CHANNEL SYSTEMS IN AGRICULTURAL WATERSHEDS

(*b*) Cooperative efforts on occasion.
(*c*) Mr. H. N. Holtan, Chief, Hydrograph Laboratory, Plant Physiology Institute, Northeastern Region, ARS-SWAS, Beltsville, Md. 20705.
(*d*) Basic and applied research.
(*e*) Specific objectives of this project are to translate the complete system of hydrodynamics, i.e., the equation of continuity, the equation of state, and the equation of motion of fluids to a system appropriate to steady or unsteady flow (with lateral inflow and outflow) on land surfaces and through open channels; to define appropriate watershed and channel initial values and boundary conditions such as, surface or channel roughness, vegetation, materials and geometry, to insure meaningful watershed solutions to the hydrodynamical equations; to develop feasible numerical methods for solving hydrodynamic equations on analog or digital computers; and to work with other members of the USDA Hydrograph Lab. to verify the surface dynamic aspects of a mathematical model of watershed performance.
(*g*) A digital model of watershed hydrology was developed for application to areas limited in size only by representation of aerial rainfall by a single raingage. Satisfactory applications have exceeded one-hundred square miles. The model is unique in that it uses linear dimensions readily available by surface or remote sensing surveys to compute volumes for storage including soil porosity, surface depressions, and contour furrows. Rates such as infiltration, surface runoff, and drainage outflow as well as groundwater recharge are then computed as exhaustion phenomenon with the rate diminishing as storage is depleted. Watersheds are zoned by similarity of most important storages (i.e. soil porosity for infiltration, or if overland flow is more important, topography would be used for zoning). Each zone is then used as a unit for hydrologic computations to derive inflow to the channel from experienced rainfall. The influences of vegetation and tillage practices are readily discernable. Plant characteristics and growth indexes are used to compute the effects of land use and treatment in modification of soil porosity. Copies of the model and computer program have been requested by a great number of action agencies and educational institutions, both foreign and domestic.
A model was developed for routing high-velocity flood flows in the main channel separately from the low-velocity flows on the floodplain. This removes the necessity for using average velocities since the uneven water surface derived from separate routings is now used to compute lateral attenuation between the main stem and the floodplains. This procedure is particularly useful in computing the energies for sediment transport, particularly in the main channel and for using the differences in energies to determine depositions on the floodplain. The model is still in the testing stage and is in process of application to actual cases in cooperation with action agencies. Both models are available in digital form either on tape or punched cards and can be obtained at no cost.
(*h*) The Hydrograph Laboratory maintains current bibliographies and abstracts of papers published since the inception of the Laboratory in 1961. These are available upon request at no cost.

301-08432-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE NORTHEAST

(*b*) Cooperative with the Vermont Agric. Expmt. Sta., New Hampshire Agric. Expmt. Sta., and NOAA.
(*c*) Ronald Z. Whipkey, Research Leader, 150 Kennedy Drive, South Burlington, Vt. 05401.
(*d*) Experimental and field observations – applied and operational research.
(*e*) Hydrologically characterize important physiographic areas of the northeast, to study the effects of land use in local watershed hydrology and on downstream water supply and water quality. Specific research includes runoff processes (surface and subsurface) kinematics of overland flow, water input to watersheds from spring melt of northern snowpack, and hydrologic characteristics of watersheds as they affect water storage, transmission, drainage, and water availability for crop growth.
(*g*) A runoff model developed for Pennsylvania uplands aids in determining maximum areas of the watershed that contribute storm runoff as well as changes of contributing area depending on time and storm characteristics. Shallow water equations were tested on a major watershed stream and kinematic and dynamic wave motions studied; physical factors of importance in flood routing through natural channels were determined from this. Water input to watersheds arising from snowmelt is greatly affected by slope-aspect-cover and elevation in the physiographical complex watersheds of northern New England.

301-09276-810-00

PREDICTING THE QUANTITY AND QUALITY OF RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE NORTHEAST

(*c*) Dr. Harry B. Pionke, Soil Scientist, Northeast Watershed Research Center, 111 Research Building A, University Park, Pa. 16802.
(*d*) Experimental and field investigation; applied research, development.
(*e*) The hydrologic, geologic properties and water quality of selected watersheds are being investigated. The purpose is to develop concepts and then to develop and test predictive models of water, sediment and chemicals origin and transport on a watershed basis.
(*g*) A storm hydrograph model based on the partial contributing area concept was developed that utilizes a physically based infiltration capacity for computation of rainfall excess and two stages of kinematic routing. Predictions of four storm hydrographs from a single watershed using this model closely approximated the observed hydrographs.
A method for selecting initial soil moisture for simulation of storm hydrographs was developed, tested and found to be highly correlated with observed data. The method assumes soil moisture values can be represented by normal probability distributions. The soil moisture values, established from soil moisture data grouped seasonally, can likely be estimated from base flow volumes if the data to establish this relationship is available.
A number of techniques for estimating daily potential evapotranspiration were evaluated. Based on lysimeter data, methods utilizing measured net or solar radiation were superior to techniques which did not utilize this input. A modified combination equation developed at Coshocton, Ohio, appeared to have considerable potential for estimating actual daily ET in the humid northeastern United States.

A survey of soluble phosphate output from an agricultural watershed in Pennsylvania during a three-year period demonstrated generally low phosphate concentrations in watershed outflow. Seasonal variations ranged from an average of 20-30 ppb in summer and 10-15 ppb in winter. Concentration in base flows averaged about 10 ppb and were relatively constant. One source of the higher phosphorus concentrations of summer flows could be plant washoff. Repeated washings of both green and dry grass tissue contained from approximately 30-170 ppb PO_4-P, the highest concentrations being generally associated with green tissue. A simulation of partial area hydrologic contribution predicted the phosphate concentration from washoff of riparian lands to contain upwards of 100 ppb PO_4-P.

(*h*) **Partial Area Hydrology and Its Application to Water Resources,** E. T. Engman, *Water Resour. Bull. 10*, 3, pp. 512-521, 1974.

Hydrologic Impact of Tropical Storm Agnes, E. T. Engman, L. H. Parmele, W. J. Gburek, *J. Hydrol.* **22,** pp. 179-193, 1974.

A Partial Area Model for Storm Flow Synthesis, E. T. Engman, A. S. Rogowski, *Water Resour. Res. 10*, pp. 464-472, 1974.

Selection of Soil Moisture Parameter for Synthesizing Storm Hydrographs, E. T. Engman, A. S. Rogowski, ASCE Natl. Water Resour. Engrg. Mtg., Los Angeles, Calif., Jan. 21-25, 1974, *Proc. Preprint 2127*, 27 pages.

A Natural Non-Point Phosphate Input to Small Streams In Processing and Management of Agricultural Wastes, W. J. Gburek, J. G. Broyan, *Proc. 1974 Cornell Agric. Waste Management Conf.*, pp. 39-50, 1974.

Soluble Phosphate Output of an Agricultural Watershed in Pennsylvania, W. J. Gburek, W. R. Heald, *Water Resour. Res.* **10,** pp. 113-118, 1974.

Comparisons of Measured and Estimated Daily Potential Evapotranspiration in a Humid Region, L. H. Parmele, J. L. McGuinness, *J. Hydrol.* **22,** pp. 239-251, 1974.

Transient Response of a Layered, Sloping Soil to Natural Rainfall in the Presence of a Shallow Water Table: Experimental Results, A. S. Rogowski, E. T. Engman, J. L. Jacoby, Jr., U. S. Dept. of Agric., *ARS-NE-30*, 61 pages, 1974.

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U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

SOUTHERN REGION, P. O. Box 53326, New Orleans, La. 70153. Dr. A. W. Cooper, Deputy Administrator.

302-0203W-830-00

SEDIMENT YIELD IN RELATION TO WATERSHED FEATURES IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 2.1175.

302-0204W-810-00

SYNTHESIS OF STREAMFLOW REGIMES IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 2.1176.

302-0205W-810-00

HYDROLOGIC PERFORMANCE OF AGRICULTURAL LANDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 2.1177 and 2.1180.

302-0206W-810-00

PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 2.1179.

302-0207W-810-00

STREAMFLOW REGIMES OF AGRICULTURAL WATERSHEDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 2.1181.

302-0208W-810-00

RUNOFF AND STREAMFLOW REGIMES OF AGRICULTURAL WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6,** 2.1366.

302-0209W-810-00

SEDIMENT YIELD IN RELATION TO WATERSHED FEATURES IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6,** 2.1367.

302-0210W-830-00

WATER EROSION CONTROL PRACTICES FOR THE TEXAS BLACKLAND PRAIRIE

See Water Resources Research Catalog **6,** 2.1377.

302-0211W-820-00

PRINCIPLES, FACILITIES AND SYSTEMS FOR GROUNDWATER RECHARGE – SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 4.0261.

302-0212W-300-00

STREAM CHANNEL MORPHOLOGY IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 2.1178.

302-0213W-810-00

PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6,** 2.1368.

302-0214W-810-00

HYDROLOGIC PERFORMANCE OF AGRICULTURAL LANDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6,** 2.1369.

302-0215W-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6,** 2.1376.

302-0216W-830-00

SEDIMENT YIELD IN RELATION TO WATERSHED AND CLIMATIC CHARACTERISTICS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6,** 2.1379.

302-0218W-820-00

GROUNDWATER IN RELATION TO USE AND MANAGEMENT OF WATERSHEDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6,** 4.0222.

302-0219W-820-00

GROUNDWATER IN RELATION TO USE AND MANAGEMENT OF WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6**, 4.0271.

302-0220W-820-00

EFFECT OF WATERSHED CHARACTERISTICS AND MANAGEMENT ON WATER SALINITY

See Water Resources Research Catalog **6**, 5.1187.

302-0221W-810-00

REMOTE SENSING FOR SPECTRAL ANALYSIS OF HYDROLOGIC VARIABLES IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6**, 7.0177.

302-7002-390-00

DEVELOPMENT AND HYDRAULIC TESTING OF CONSERVATION STRUCTURES AND WATERFLOW MEASURING DEVICES

See U. S. Department of Agriculture, Agricultural Research Service, North Central Region, Project 01723.
(*b*) Cooperative with the Oklahoma Agric. Exp. Station.
(*c*) Dr. W. R. Gwinn, Hydraulic Engineer, P. O. Box 551, Stillwater, Okla. 74074.
(*d*) Experimental, applied research.
(*e*) Develop and test hydraulic structures for soil and water conservation works. Test small-scale and full-size models of structures and appurtenances in laboratory basins. Determine general hydraulic performance, head loss coefficients, pressure coefficients and related hydraulic phenomena. Structures required for flow measurement in the hydrology research program of the Agricultural Research Service, U. S. Department of Agriculture, are developed for sites where standard structures are not practical. Such sites include steep sand-laden streams and streams having very flat gradients. Consideration is given to scour, backwater and channel control effects. Modifications to existing drainage structures to make them suitable for runoff measurement are devised and tested. (Also listed in Water Resources Research Catalog 6, 6.0179, 7.0180, and 8.0455.)
(*g*) Trash racks on closed conduit spillways for floodwater retarding reservoirs have been tested with clear water flows and with flows carrying hay or sticks. Relative efficiencies of various rack designs have been determined. A complex of channels and structures comprising an urban floodwater disposal system has been tested. Nine large supercritical flow measuring flumes with capacities up to 22,500 cfs have been designed and calibrated. Eight highway culverts equipped with V-notch weirs have been calibrated. Model studies of two highway bridge sites have been made to determine the effect of the addition of weirs for low flow measurement. Protection of the bridge foundations from scour was a consideration.

302-09286-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE SOUTHEAST

(*b*) Cooperative with the Univ. of Georgia Agric. Exp. Sta., Georgia Inst. of Technology, North Carolina Agric. Exp. Sta., Univ. of Florida Agric. Exp. Sta., Soil Conservation Service, and the Central and Southern Florida Flood Control District.
(*c*) Dr. Walter G. Knisel, Jr., Hydraulic Engineer and Laboratory Chief, Southeast Watershed Laboratory, USDA-Agricultural Research Service, P. O. Box 469, Athens, Ga. 30601.
(*d*) Experimental, theoretical, and field investigations; basic and applied research.
(*e*) Determine statistics of rainfall and runoff, develop methods to estimate design values of runoff and streamflow for basin development, build models to predict hydrologic response of watersheds with improved agricultural management. Watershed processes will be conceptualized in mathematical models, each specific to a prediction problem. Models will be verified and improved through field research on agricultural watersheds in the Coastal Plains of Georgia, North Carolina, Florida, and Mississippi, but centered in Little River, Tifton, Georgia. Basin precipitation, streamflow, groundwater, and climate data will be processed by mathematical-statistical techniques to develop base data and model components. Mapping techniques will be developed to incorporate physical, geological, and management practice characteristics in the models.
(*g*) The nonlinear five-day water yield model was modified to include an estimate of watershed retention storage. Storage was made a function of season and antecedent rainfall. The model is programmed in analytical mode for finding best values of parameters and in prediction mode for calculation of runoff volumes from rainfall when parameters are known. The two-stage convolutional storm hydrograph model has been simplified and programmed in analytical mode. Search for best values of parameters in three model components is possible over a variable number of storms of variable rainfall duration. The pioneer work in estimation of parameters of statistical frequency distributions has been extended. The log-transform with embedded normal distribution was modified so that it can be fitted simultaneously to samples of meteorological and hydrologic variates for each of the twelve calendar months of the year. The twelve monthly distributions form a mathematically continuous seasonally cyclic set. Simulation with this new statistical form is explicit and produces probabilistic ranges of expectancy of future extreme events. A parametric model was developed to predict mean daily streamflow volumes during hydrograph recessions. The model components include a characteristic and routing function which are parametrically defined. With an initial daily discharge rate and convolution of the characteristic and routing functions, mean daily streamflow can be estimated for sustained periods.
(*h*) **Subsurface Hydrograph Analysis by Convolution,** W. M. Snyder, L. E. Asmussen, *J. Irrig. and Drain. Div., ASCE* **98, IR3**, pp. 405-418, Sept. 1972.
Fitting of Distribution Functions by Non-Linear Least Squares, W. M. Snyder, *Water Resour. Res.* **8,** 6, pp. 1423-1432, Dec. 1972.
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Adaptation of Quartz Clock Movement Makes Low-Cost Timers, L. E. Asmussen, H. D. Allison, J. M. Sheridan, *J. Agr. Engr., ASAE* **55,** 5, p. 29, May 1974.
Why Should We Predict Runoff for Ungaged Drainage Areas?, W. M. Snyder, W. G. Knisel, Jr., *J. Soil and Water Conserv.* **29,** 5, pp. 229-232, Sept.-Oct. 1974.
Pan Evaporation at the Georgia Coastal Plain Experiment Station, J. M. Sheridan, L. E. Asmussen, W. G. Knisel, Jr., *Res. Bull. 159*, 29 pages, Dept. of Agronomy, Coastal Plain Expt. Sta., Tifton, Ga., Oct. 1974.

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Storm Hydrographs by Two-Stage Convolution – Detailed Form of Computations, W. M. Snyder, Station Paper, *LAB NOTE SEWL 047401*, 11 pages, 1974. (Avail. upon request to correspondent.)

302-09287-860-00

WATER QUALITY IN AGRICULTURAL WATERSHEDS OF THE SOUTHEAST

(*b*) Cooperative with Univ. of Georgia Agric. Exp. Sta., Georgia Inst. of Tech., and Middle South Georgia Soil Conservation District.

(*c*) Dr. Walter G. Knisel, Jr., Hydraulic Engineer and Laboratory Chief, Southeast Watershed Laboratory, USDA-Agricultural Research Service, P. O. Box 469, Athens, Ga. 30601.

(*d*) Experimental, theoretical, and field installation; basic and applied research.

(*e*) To quantify quality parameters in surface and shallow groundwater in agricultural watersheds, and develop methods for alleviating undesirable qualities in these waters. Concentrations of plant nutrients, pesticides, sediment, and other materials will be related to such hydrologic parameters as flow rates and flow paths, and quantity of surface and subsurface water, and to land management. Response functions for water quality will be related to chemical characteristics, spatial configuration and treatment of watersheds. A routing function will describe the water quality translating capability of the watershed.

(*g*) A model was developed to predict sediment yield by including a discharge-sediment load rating curve with the five-day water-yield model. The model is operational but needs numerical calibration from historical records. A subroutine was added to the storm hydrograph model to compute rill and interrill sources of sediment in headwaters areas. The water and sediment phases provide the carriers for chemicals in a storm water quality model. Four years of data from an 0.8 acre Coastal Plain area show NO_3 -N loss ranged from 0.11 to 0.39 lb/ac/yr in surface runoff and 19.7 to 41.8 lb/ac/yr in subsurface flow. Weighted average concentrations ranged from 0.17 to 0.43 ppm and 7.1 to 10.5 ppm for surface and subsurface, respectively. 2,4-D concentrations in water and sediment from a small plot decreased exponentially for 1, 8, 35, and 114 days after application. Only 1.46 percent of applied 2,4-D was recovered in runoff and sediment. An 80-ft grassed waterway removed 72 percent of the 2,4-D at the end of the plot one day after application when the soil was dry. Good quality streamflow from agricultural watersheds diluted poorer quality water from urban areas for seven characteristics observed in the Coastal Plain. Water quality was related to population density. Seasonal effects on water quality were found in urban areas but were not significant in agricultural areas.

(*h*) **Nitrate in Surface and Subsurface Flow from a Small Agricultural Watershed,** W. A. Jackson, L. E. Asmussen, E. W. Hauser, A. W. White, *J. Environ. Qual.* **2**, 4, pp. 480-482, Oct.-Dec. 1973.

302-09288-810-00

FREQUENCY ESTIMATION OF SOIL-, AIR-, AND WATER-RELATED VARIABLES

(*b*) Cooperative with Georgia Institute of Technology.

(*c*) Dr. J. R. Wallace, Assoc. Professor, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332, and Mr. W. M. Snyder, Hydraulic Engineer, Southeast Watershed Laboratory, USDA-Agricultural Research Service, P. O. Box 469, Athens, Ga. 30601.

(*d*) Experimental and theoretical; basic and applied research.

(*e*) Develop and test a new method for estimating the frequency of occurrence of a large class of climatological and hydrological variables. Select variables on the basis of relevance to agricultural and planning and engineering for soil and water conservation. Develop methods for assigning probability levels based on probability density form of distribution, with a goal of developing a universal method for frequency analysis by fitting data to probability density functions combined with variate transformation procedure. Analyze the stability of the computational methods with respect to such parameters as class interval, number of values per interval, and shape of the sample distribution. Apply the method to important agricultural variables such as precipitation and frost-free days. Perform a massive analysis with a wide range of data and study sampling distributions of the transformation parameters.

(*g*) The theoretical basis for fitting statistical frequency distributions to sample histograms by nonlinear least squares was established. It was mathematically demonstrated that this method is equivalent to the method of maximum likelihood for classified data. By proper choice of weighting function the method can be made to vary from straightforward regression to an iterative implementation of the method of minimum chi-square. The method of nonlinear least squares was compared to the method of maximum likelihood using the two-parameter gamma distribution fitted to many synthetic samples. It was found that reduction in statistical efficiency for the least squares parameters could be practically eliminated by proper choice of weights. Least squares estimators were found not sensitive to class width. The great advantage of the least squares parameters is that they are not sensitive to outliers, those extreme events which occur in a short hydrologic record.

(*h*) **Fitting a Three-Parameter Log-Normal Distribution by Least Squares,** W. M. Snyder, J. R. Wallace, *Nordic Hydrol.* **5**, pp. 129-145, 1974.

Statistical Frequency Analysis by Optimization of Density Functions to Histograms, J. L. Grant, *Dissertation*, Georgia Institute of Technology, Nov. 1973. (Avail. upon request to correspondent.)

302-09289-810-00

ESTIMATING WATER YIELD FROM SOUTHERN PIEDMONT WATERSHEDS

(*b*) Cooperative with Clemson University, Clemson, S. C.

(*c*) Drs. T. V. Wilson and J. T. Ligon, Professors, Agr. Engr. Dept., Dr. A. G. Law, Professor, Civil Engr. Dept., Clemson University, Clemson, S. C. 29631, and W. M. Snyder, Hydraulic Engr., Southeast Watershed Laboratory, USDA-Agricultural Research Service, P. O. Box 469, Athens, Ga. 30601.

(*d*) Experimental and theoretical; basic and applied research.

(*e*) Evaluate a three-component, nonlinear, five-day water-yield model and investigate relationships between model parameters and watershed physical characteristics. One southern Piedmont watershed with complete hydrologic data will be used to test optimization schemes for determining best model version. Selection criteria will be determined by sensitivity and consistency analyses. Selected model version will be applied in analysis mode to other Piedmont watersheds to ascertain correlations and relationships between model parameters and watershed physical characteristics.

(*g*) The five-day water-yield model was applied in the analysis mode to data from a Piedmont watershed. The characteristic function of the original model version did not give adequate correspondence between observed and predicted streamflow. The function was reworked to more efficiently consider rapid watershed response as well as long-term delayed response.

302-09290-220-00

EFFECTS OF BED FORMS ON THE SUSPENSION AND BEDLOAD TRANSPORT OF SEDIMENT

(*c*) Joe C. Willis, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.

(*d*) An experimental investigation of the basic mechanics of bed forms and bedload transport. Part of the results will be applied toward a Doctoral thesis.
(*e*) Statistical descriptions of bed forms under different flow and temperature controls are being obtained from a laboratory test channel. Objectives of the study are to define relationships for the statistical parameters of bed forms and to incorporate these relationships along with sediment suspension models into a method for predicting the total, bed-material load.

302-09291-220-00

INFLUENCE OF SUSPENDED SEDIMENT ON THE REAERATION RATE OF UNIFORM STREAMS

(*b*) Cooperative with the Water Resources Research Institute of Mississippi State University, University of Mississippi, and Mississippi Agricultural and Forestry Experiment Station.
(*c*) C. V. Alonso, Research Hydraulic Engineer and J. R. McHenry, Soil Scientist, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental, analytical, basic and applied research.
(*e*) Laboratory and analytical studies to determine the combined influence of the bulk-flow hydraulic variables and the physical properties of the suspended sediment on the surface reaeration rate of sediment laden flows in straight open channels. Measurements of velocity and suspended sediment distributions were conducted in a 50-ft recirculating flume for different flow conditions. The corresponding surface-reaeration rates were determined using a Lagrangian technique which measures the rate of change of the oxygen deficit in a parcel of deaerated water moving with the average longitudinal velocity of the flow.
(*f*) Completed.
(*g*) Based on the premise that the reaeration rate is controlled by an effective vertical diffusivity at the free surface and by turbulent mixing beneath it, a mathematical model was developed to predict the reaeration rate of uniform clear-water flows. The laboratory data gave support to the developed model. This model was then modified to account for the effect of suspended sediments on the surface reaeration rate of uniform sediment-laden streams. The new model was substantiated by experimental results, which indicate that the reaeration rate decreases as the average sediment concentration increases. The decrease was attributed to the dynamic influence of the suspended particles on the turbulent flow field.
(*h*) **The Influence of Suspended Sediment on the Surface Reaeration of Uniform Streams,** C. V. Alonso, J. R. McHenry, J.-C. S. Hong, *Completion Report OWRR A-062-MISS*, Miss. Water Resour. Res. Inst., Miss. State Univ., 50 pages, 1973.
The Influence of Suspended Sediment on the Surface Reaeration of Uniform Streams, C. V. Alonso, J. R. McHenry, J.-C. S. Hong, *Water Res.* (to appear), 1975.
The Influence of Suspended Sediment on the Surface Reaeration of Uniform Streams, J.-C. S. Hong, *M.Sc. Thesis*, Dept. Civil Engrg., Univ. Mississippi, University, Miss., 1974.

302-09292-200-00

TURBULENT FLOW STRUCTURE AND TIME AND SPATIAL DISTRIBUTION OF BOUNDARY SHEAR STRESS IN OPEN CHANNEL FLOWS

(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental, analytical, basic and applied research.
(*e*) In an alluvial channel composed of granular bed material, the transport of such material is strongly dependent on the turbulent structure of flow near the bed. This transport process is further complicated by the random nature of slowly moving large bed features such as ripples, dunes, and antidunes. Evidently, the postulation of an adequate sediment transport model requires a satisfactory understanding of the time and spatial distribution of the instantaneous hydrodynamic forces near the channel bed. This research is being carried on in an 18 m long and 60 cm wide stainless steel open channel flume system. Digital time series analysis procedures will be used to analyze both near-bed turbulent velocity and boundary shear stress fields. This investigation will study the spatial variation of the statistical moments and probabilistic distribution of the instantaneous boundary shear stress with varying flow conditions; determine the influence of channel geometry and flow variables on the probability distribution parameters; study the structure of turbulence near a smooth bed and a sine-wave bed for different flow conditions; analyze the turbulent structure in terms of local and flow Reynolds numbers, channel resistance and geometry, sublayer intermittency and probabilistic distribution of the instantaneous boundary shear stress, areal distribution of boundary shear stress and turbulent eddy scales near the bed, and distribution of the turbulent energy in flow profile.

302-09293-220-00

LOCAL FLOW AND FORCES EXERTED ON A STREAMBED PARTICLE

(*c*) N. L. Coleman, Geologist, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental, basic and applied research.
(*e*) Laboratory experiments to determine lift and drag coefficient functions for particles on a streambed. Measurements of drag and lift forces, flow velocities, and other relevant variables are being made during experiments in a water tunnel.

302-09294-350-00

DESIGN CRITERIA FOR WATER CONTROL STRUCTURES

(*b*) Cooperative with the University of Mississippi, Mississippi State University and the Soil Conservation Service.
(*c*) Dr. W. C. Little, Hydraulic Engineer and Mr. J. B. Murphey, Geologist, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.
(*d*) Field and laboratory investigations; basic and applied research.
(*e*) Develop and evaluate techniques for the design of riprap grade control structures. Investigate, by hydraulic model studies and field studies, the optimum geometry of energy dissipation pools for loose-rock drop structures. Areas of investigation include the influence of plan geometry, channel shape, channel gradient, flow parameters and rock size. Additionally, various techniques for energy dissipation within a preformed scour hole are being investigated.
(*g*) Model studies have shown that additional energy dissipation mechanisms are needed even with preformed, rock lined scour holes. Model studies showed that when the ratio of specific head to drop is greater than one, a well-developed hydraulic jump does not occur and an undulating jump generates undesirable standing waves which persist large distances downstream. Various forms of both baffle blocks and baffle plates have been shown to be extremely effective in destroying the undulating waves and reducing the erosion potential of the water as it enters the downstream channel.

302-09295-300-00

STREAM CHANNEL STABILITY

(*b*) Cooperative with the University of Mississippi, Mississippi State University and the Soil Conservation Service.
(*c*) Dr. Earl H. Grissinger, Soil Scientist and Dr. W. C. Little, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.
(*d*) Field and laboratory investigations; basic and applied research.
(*e*) Using multivariate statistical techniques, identify the soil physiochemical properties that are significant channel erodibility parameters and statistically relate eroding shear stress to the soil parameters.

302-09296-220-00

SEDIMENT PROPERTIES THAT AFFECT AGRICULTURAL CHEMICAL TRANSPORT

(*b*) Cooperative with Mississippi Agricultural and Forestry Experiment Station and the University of Mississippi.

(*c*) L. L. McDowell and J. D. Schreiber, Soil Scientists, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.

(*d*) Experimental and field investigations; basic and applied research.

(*e*) Develop soil and water conservation programs to minimize the transport of farm chemicals from croplands; determine quantity and forms of farm chemicals from croplands; determine quantity and forms of farm chemicals transported in surface runoff from upland and Delta farmlands; evaluate relative significance of solution-and sediment-phase chemical transport; evaluate minimum tillage practices for reducing chemical losses from farmlands; determine physical and chemical properties of sediments that affect chemical transport; chemical trap efficiency of small impoundments; develop sediment-water-chemical relationships needed for predicting the transport of farm chemicals.

(*g*) Plant nutrient losses and sediment chemical oxygen demand (COD) were measured in the runoff from conventional and no-till soybeans, corn, and wheat grown on highly erodible soils in north Mississippi. Total (solution plus sediment) N and P losses from no-till soybeans were 4.2 and 2.5 pounds per acre, respectively, compared to 41.4 and 15.7 pounds per acre from conventional tillage. Annual sediment-COD was reduced from 1050 to only 90 pounds per acre by no-till. Soluble P concentrations and losses from no-till were higher than from conventional because of differences in the physiochemical properties of sediments and sediment-chemical interactions. Sediment and plant nutrient losses from forested watersheds in north Mississippi were low, even when annual rainfall was 40 percent above average, and should pose no environmental hazard. Studies indicate that reservoirs can trap large quantities of phosphorus (P), but the amount trapped depends on the form of P. A midwest reservoir trapped 70 percent of the sediment-P and only 30 percent of the soluble form. Outflow loadings of dissolved organic and hydrolyzable forms were greater than inflow loadings.

(*h*) **Field Performance and Evaluation of Two Automatic Suspended Sediment Pumping Samplers,** C. E. Murphree, L. L. McDowell, G. C. Bolton, A. J. Bowie, *Proc. Miss. Water Resour. Conf.*, p. 1-17, 1972.

Surface Water Quality, R. F. Holt, H. P. Johnson, L. L. McDowell, *Proc. Natl. Conserv. Tillage Conf.*, Des Moines, Iowa, pp. 141-156, 1973.

An Automatic Pumping Sampler for Evaluating the Transport of Pesticides in Suspended Sediment, J. F. Parr, G. H. Willis, L. L. McDowell, C. E. Murphree, S. Smith, *J. Environ. Qual.* **3,** 3, pp. 292-294, 1974.

302-09297-220-00

SEDIMENT DEPOSITION

(*b*) Cooperative with the University of Mississippi and Mississippi Agricultural and Forestry Experiment Station.

(*c*) Roger McHenry, Soil Scientist; F. E. Dendy, Hydraulic Engineer; J. C. Ritchie, Soil Scientist; F. R. Schiebe, Hydraulic Engineer; J. May, Chemist; USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.

(*d*) Experimental laboratory and field studies; basic and applied research.

(*e*) Evaluate reservoir, hydrologic, hydraulic, and watershed factors affecting the rate, amount, character and areal distribution of sediment deposition in reservoirs, lakes, streams and estuaries. Study the bio-physio-chemical aspects of sediment-water systems in lakes, impoundments, and estuaries and relate these to management techniques. Design, develop, test, evaluate, modify, and adopt techniques, methods and instrumentation to characterize significant variables in sediment-water systems in field and laboratory. Compile and analyze existing reservoir sedimentation data including trap efficiency percentages directly by inflow and outflow measurements and indirectly using nuclear and remote sensing techniques. Sedimentation rates and ages are determined by nuclear means and newer techniques, as remote sensing, are applied to re-evaluation of sedimentation data. Automation of data collection and digital modeling of sedimentation are essential.

(*g*) Data over an extended period of time indicate the trap efficiencies of small reservoirs varied over a relatively small range, 81 to 98 percent. This is in spite of widely varying reservoir size, slope, and sediment inflow rates and volume. Trap efficiencies for normally dry reservoirs were essentially the same as ponded reservoirs. Nutrient contents of sediments in selected reservoirs were lower in N, C, and organic P than the surface soils of the contributing watersheds and higher in inorganic P. A significant linear relationship ($r = 0.90$) exists between total suspended solids in reservoirs and their reflected light at wavelength of 750 nm for four north Mississippi reservoirs. A monitoring program is under way to assess the relationship throughout the year. Continued development of nuclear gages has provided reliable and sturdy instruments for *in situ* measurements of sediment densities and suspended sediment concentrations with an accuracy of 0.05 lb/ft^2 and 0.2 gm/ml, respectively. Sediment movement into and out of reservoirs is monitored by sedimentation surveys. Using cesium-137 as a tag, studies indicate that concentrations of that radioisotope do occur in reservoirs where sediments are deposited. Because of the affinity of cesium-137 for clay and organic particles, it is possible to postulate erosion rates from sediment desposition rates if the trap efficiency of the system is known. Present studies of mass balance of cesium-137, clay, and organic constituents for a watershed are being conducted to evaluate the full potentiality of the use of cesium-137 in erosion and sedimentation studies.

(*h*) **Sediment Trap Efficiency of Small Reservoirs,** F. E. Dendy, *ASAE Trans.* **17,** pp. 898-901, 1974.

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Accumulation of Fallout Cesium-137 in Soils and Sediments in Selected Watersheds, J. R. McHenry, J. C. Ritchie, A. C. Gill, *Water Resour. Res.* **9,** pp. 676-686, 1973.

Sedimentation Research in Mississippi: Progress and Goals, J. R. McHenry, A. R. Robinson, *Proc. Mississippi Water Resour. Conf. 1974*, pp. 23-34, 1974.

Thorium, Uranium and Potassium in the Upper Cretaceous, Paleocene, and Eocene Sediments of the Little Tallahatchie River Watershed in Northern Mississippi, J. C. Ritchie, P. H. Hawks, J. R. McHenry, *Southeastern Geology* **14,** pp. 221-229, plus append., 3 pages, 1972.

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Estimating Soil Erosion from the Redistribution of Fallout Cs-137, J. C. Ritchie, J. A. Spraberry, J. R. McHenry, *Proc. Soil Sci. Soc. Amer.* **38,** pp. 137-139, 1974.

302-09298-830-00

SEDIMENT YIELD RESEARCH

(*b*) Cooperative with Mississippi Agricultural and Forestry Experiment Station and the Soil Conservation Service.
(*c*) Calvin K. Mutchler, Research Leader, USDA Sedimentation Laboratory, P. O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental; applied and basic research.
(*e*) Develop methods for describing and controlling the movement of water and sediment from upland, field, and channel sources to a watershed outlet. The field facilities are 1) Pigeon Roost Creek Watershed in North Mississippi, consisting of ten gaged subwatersheds covering 117 square miles; 2) four flatland watersheds in the Mississippi Delta, a divided one of 83 acres, a natural Delta watershed of 600 acres, and two 8-acre graded field segments; 3) Toby Tubby Creek Watershed, 1000 acres and partly urbanized; 4) erosion plots sited on the North Mississippi Branch Experiment Station; and 5) two laboratory rainfall simulators and computer facilities shared with other research units at the Laboratory. Primary objectives of the research are to document runoff and sediment yield from watersheds under changing cover, agricultural usage, and urbanization; to determine delivery ratios and other sediment yield prediction methods; to develop methods for controlling erosion from farm fields and other watershed sediment sources; to investigate hydraulic and hydrologic effects of channel dredging; to determine effects of urbanization on water and sediment yield; to investigate the relationship of rill and interrill erosion and sediment transport; and to investigate the physical-chemical basis of soil erodibility.
(*h*) **Traversing-Plot Runoff Samplers for Small Watersheds,** F. E. Dendy, *ARS-S-15*, Aug. 1973.
Good News From the Search for Better Erosion Control Methods, L. D. Meyer, *Construction Digest* **46,** 4, pages 52, 54, 56, 1973.
Phosphorus Relationships in Runoff From Fertilized Soils, M. J. M. Romkens, D. W. Nelson, *J. Environ. Qual.* **3,** pp. 10-13, 1974.
The Influence of Vegetation and Vegetative Mulches on Soil Erosion, L. D. Meyer, J. V. Mannering, in *Biological Effects In The Hydrological Cycle. Proc. 3rd Intl. Sem. Hydrology Professors*, Purdue Univ., W. Lafayette, Ind., July 18-30, 1971.
Overview of the Urban Erosion and Sedimentation Process, L. D. Meyer, *Proc. Natl. Symp. Urban Rainfall and Runoff and Sediment Control*, Lexington, Ky., July 29-31, 1974.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

WESTERN REGION, 2850 Telegraph Avenue, Berkeley, Calif. 94705. Dr. H. R. Thomas, Deputy Administrator.

303-0196W-810-00

REYNOLDS CREEK EXPERIMENTAL WATERSHED STUDY

See Water Resources Research Catalog **6,** 2.0582.

303-0201W-810-00

EFFECT OF RUNOFF, PRECIPITATION, CLIMATE, SOIL, VEGETATION, LAND USE, AND LANDFORM ON SEDIMENT YIELD

See Water Resources Research Catalog **6,** 4.0120.

303-0202W-810-00

CLIMATE, SOIL, AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE NORTHWEST

See Water Resources Research Catalog **6,** 7.0093.

303-0225W-820-00

RELATION OF SALINITY TO STATE AND TRANSPORT OF WATER AND IONS IN SOIL AND PLANTS

See Water Resources Research Catalog **6,** 1.0014.

303-0226W-820-00

GROUNDWATER RECHARGE AND MANAGEMENT IN CALIFORNIA

See Water Resources Research Catalog **6,** 4.0044.

303-0227W-810-00

CLIMATE, SOIL AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE SOUTHWEST

See Water Resources Research Catalog **6,** 2.0045.

303-0228W-810-00

STREAM FLOW REGIMES OF SEMIARID RANGELAND WATERSHEDS IN THE SOUTHWEST

See Water Resources Research Catalog **6,** 2.0046.

303-0229W-810-00

PRECIPITATION PATTERNS ON RANGELAND WATERSHEDS IN THE SOUTHWEST

See Water Resources Research Catalog **6,** 2.0047.

303-0230W-300-00

FLOOD WAVE MOVEMENT IN NATURAL EPHEMERAL STREAM CHANNELS

See Water Resources Research Catalog **6,** 2.0048.

303-0231W-830-00

SEDIMENT YIELD FROM RANGELAND WATERSHEDS IN THE SOUTHWEST

See Water Resources Research Catalog **6,** 2.0049.

303-0232W-810-00

PREDICTING RUNOFF AND STREAM FLOW FROM WATERSHEDS IN THE SOUTHWEST

See Water Resources Research Catalog **6,** 2.0050.

303-0234W-820-00

SOIL WATER MOVEMENT IN RELATION TO THE CONSERVATION OF WATER SUPPLIES

See Water Resources Research Catalog **6,** 3.0004.

303-0235W-840-00

EFFICIENT IRRIGATION AND AGRICULTURAL WATER USE

See Water Resources Research Catalog **6,** 3.0005.

303-0236W-860-00

INCREASING AND CONSERVING FARM WATER SUPPLIES

See Water Resources Research Catalog **6,** 3.0006.

303-0238W-810-00

SUPPRESSION OF EVAPORATION FROM WATER SURFACES

See Water Resources Research Catalog **6,** 4.0008.

303-0239W-860-00

PRINCIPLES, FACILITIES, AND SYSTEMS FOR WATER HARVEST

See Water Resources Research Catalog **6,** 4.0009.

303-0240W-860-00

METHODS FOR WATER QUALITY IMPROVEMENT AND ITS STORAGE UNDERGROUND

See Water Resources Research Catalog **6**, 5.0059.

303-0241W-840-00

IRRIGATION SYSTEMS FOR EFFICIENT WATER USE

See Water Resources Research Catalog **6**, 8.0004.

303-0350W-840-00

MANAGEMENT OF IRRIGATION WATER IN RELATION TO CROP REQUIREMENTS, NUTRIENT UTILIZATION AND LABOR REQUIREMENTS

See Water Resources Research Catalog **9**, 3.0122.

303-0351W-840-00

ALLEVIATION OF SALT LOAD IN IRRIGATION WATER RETURN FLOW

See Water Resources Research Catalog **9**, 5.0247.

303-0352W-840-00

DESIGN AND OPERATION OF IRRIGATION SYSTEMS TO MAXIMIZE EFFICIENCIES OF WATER USE

See Water Resources Research Catalog **9**, 8.0123.

303-0353W-860-00

PLANT GROWTH AND WATER USE IN THE NORTHERN PLAINS

See Water Resources Research Catalog **9**, 3.0113.

303-0354W-070-00

FLOW IN POROUS MEDIA IN RELATION TO DRAINAGE DESIGN AND DISPOSAL OF POLLUTANTS

See Water Resources Research Catalog **9**, 8.0122.

303-0355W-820-00

MEASUREMENT, PREDICTION AND CONTROL OF SOIL-WATER MOVEMENT IN ARID SOILS

See Water Resources Research Catalog **9**, 2.0322.

303-0356W-810-00

RUNOFF CONTROL BY MANIPULATION OF SOIL PROPERTIES

See Water Resources Research Catalog **9**, 4.0079.

303-0357W-840-00

REDISTRIBUTION AND DRAINAGE OF SOIL WATER FOLLOWING IRRIGATION

See Water Resources Research Catalog **7**, 2.1406.

303-0358W-840-00

INFILTRATION CONTROL AND SOIL WATER REDISTRIBUTION IN RELATION TO IRRIGATION

See Water Resources Research Catalog **7**, 2.1407.

303-0359W-840-00

INFILTRATION CONTROL IN RELATION TO NORTHWEST IRRIGATION REQUIREMENTS

See Water Resources Research Catalog **7**, 4.0376.

303-0360W-830-00

TILLAGE, CROP AND RESIDUE PRACTICES FOR CONTROL OF EROSION IN THE NORTHWEST

See Water Resources Research Catalog **8**, 3.0394.

303-0361W-880-00

INTERAGENCY FRAIL LANDS STUDY – MONTANA

See Water Resources Research Catalog **9**, 2.0696.

303-0362W-810-00

EFFECT OF RANGE MANAGEMENT PRACTICES ON SURFACE RUNOFF

See Water Resources Research Catalog **9**, 4.0140.

303-05209-840-00

DEVELOPMENT OF IMPROVED SURFACE IRRIGATION SYSTEMS

(*c*) A. S. Humpherys, Agr. Engr., Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho.
(*d*) Experimental, field investigations; applied research and development.
(*e*) Develop improved surface systems for the control and application of irrigation water. Devices, structures and techniques for manual, semiautomatic and automatic application of irrigation water will be developed to enable more efficient use of farm water supplies and reduce soil erosion and sedimentation. Structures and devices are tested in the laboratory and the field to determine their hydraulic characteristics and to evaluate the design, performance and adaptability to field conditions. Complete systems will be field tested to evaluate their water and labor requirements and ability to control erosion.
(*g*) Automatic, low pressure pipeline valves and the associated controls for surface irrigation have been developed. These are particularly well-suited for use with gated pipe and have been designed for 6-, 8- and 10-inch pipe. The valves operate on water from the pipeline and the battery-powered control units use both mechanical and electrical timers. In addition to being used in conventional gated pipe systems, the valves are being tested in automatic-cutback and multiset furrow irrigation systems to increase water use efficiency and to reduce field runoff and soil loss. Concrete-pipe ditch turnouts are being semi-automated using timers for border irrigation.
(*h*) **Automatic Controls for Surface Irrigation Systems,** A. S. Humpherys, *Proc. IFAC Symp. Automatic Controls for Agriculture*, C-6, pp. 1-16, Comm. Automatic Control, Natl. Res. Council of Canada, Saskatoon, June 18-20, 1974.
Automated Valves for Surface Irrigation Pipeline Systems, A. S. Humpherys, R. L. Stacey. To be published in *Trans. ASCE J. Irrig. and Drain. Division.*

303-08434-840-00

REGIONAL WATER MANAGEMENT STUDY – JEFFERSON COUNTY, IDAHO

(*b*) Cooperative with the University of Idaho.
(*c*) James A. Bondurant, Agr. Engr., USDA-ARS-WR, Route 1, Box 186, Kimberly, Idaho 83341.
(*d*) Theoretical and field investigation; applied research.
(*e*) Numerous complex irrigation water management problems exist in the older irrigation projects of the Western U. S. where unlined, multiple canal systems are operated by numerous small canal companies. Typical problems involve high diversion requirements because of high seepage losses accompanied by high groundwater levels. Progress toward modernizing the delivery systems and solving these problems is hampered by lack of local incentives, finances, methods and authorities for consolidating multiple canal systems, methods for reducing system losses, and on-farm water management practices that have not changed in decades. The purpose of this study is to develop a general systematic method of evaluating the major causes of the project-wide problems and to develop general mathematical models that can be used to evaluate alternative solutions or corrective measures. The primary problem encountered in this area of study involves high groundwater levels that annually result in extensive property damage.
(*f*) Completed.

(g) Three years of data were collected. A computer model for simulating groundwater levels was developed. Water management alternatives for relieving high water tables have been presented to the area residents.
(h) **Systems Analysis of Irrigation Water Management in Eastern Idaho,** C. E. Brockway, J. deSonneville, Water Resources Insitute, Univ. of Idaho, Oct. 1973.

303-09312-840-00

DESIGN AND OPERATION CRITERIA FOR IRRIGATION RETURN FLOW SEDIMENT PONDS

(c) James A. Bondurant, Agr. Engr., USDA-ARS-WR, Route 1, Box 186, Kimberly, Idaho 83341.
(d) Theoretical and field investigation; applied research.
(e) Many irrigation systems have runoff streams which contribute sediment to a receiving stream. The sediment may carry pesticides, herbicides, phosphorus and nitrogen which may contribute to further degradation of receiving streams. Much of this sediment may be trapped in ponds built either for an individual field, farm, or for a project wasteway. The purpose of this study is to develop methods and criteria to use in designing efficient sediment ponds considering flow rates, sediment size, and quality.
(g) Sediment ponds have been constructed for study purposes. Trapping efficiencies have ranged from 30 to 90 percent, and was best at higher flows which have a greater concentration of larger particle sizes.

303-09315-810-00

INFLUENCE OF CLIMATIC, BIOLOGIC, AND PHYSICAL FACTORS ON RANGELAND WATERSHED HYDROLOGY

(c) L. M. Cox, Hydrologist, Northwest Watershed Research Center, P. O. Box 2700, Boise, Idaho.
(d) Experimental, applied research.
(e) Develop, test, and apply methods for measuring and predicting snow water distribution for continuous and discontinuous (drift) snowpack areas; test and improve snowmelt computation procedures for long-term and short-term (approaching real time) forecast periods. Provide precipitation inputs compatible with watershed modeling requirements. Develop and test watershed models for runoff prediction and stream channel flow conveyance consistent with needs for predicting environmental impact of rangeland management on water quality and supply. Approach will be to correlate with ground truth snowfall computed from dual gage system and photogrammetric analysis. Analyze precipitation network to provide watershed model input and determine whether size can be reduced. Compare snowmelt forecasts from models with action agency forecasts and discuss improvements with agencies. Test watershed models involving runoff production and channel routing procedures using existing data sets and implement appropriate data network changes. Cooperate with State and Federal units in utilization of watershed models to study environmental impact of range uses.
(g) Improved forecast procedures have been developed for snowmelt runoff. A dual precipitation gage system is operational for measuring snowfall under blowing conditions.
(h) **Dual Gage and Profile Techniques for Calculating Actual Precipitation,** W. R. Hamon, Commission for Instr. and Methods of Observations, World Met. Org., Geneva, Switzerland, *Pub. Annex 3*, First Session, Oct. 1970.
Overland Flow on Rangeland Watersheds, D. A. Woolhiser, C. L. Hanson, A. R. Kuhlman, *J. Hydrol* (*N.Z.*) **9**, 2, pp. 336-356, 1970.
Field Performance of the Universal Surface Precipitation Gage, L. M. Cox, *Western Snow Conf. Proc. 540-71*, pp. 84-88, 1971.
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Optimizing Resistance Coefficients for Large Bed Element Streams, D. E. Overton, H. E. Judd, C. W. Johnson, *PRWG-59a-1*, Utah Water Res. Lab., College of Engr., Utah State Univ., Logan, 1972.
Forecasting Runoff from Universal Surface Gage Snowmelt Measurements, L. M. Cox, J. F. Zuzel, *J. Soil and Water Cons.* **28**, 3, pp. 131-134, 1973.
Forecasting Runoff from Universal Surface Gage Snowmelt Measurements, L. M. Cox, J. F. Zuzel, *World Met. Org. Symp. on the Role of Snow and Ice in Hydrol., Pub. Proc.*, pp. 1089-1097, Banff, Alberta, Canada, 1973.
Winter Storm and Flood Analysis, Northwest Interior, C. W. Johnson, R. P. McArthur, *Hydraul. Engrg. and the Environment, Proc. Hydraul. Div. Spec. Conf.*, pp. 359-369, Bozeman, Mont., 1973.

303-09316-810-00

INFLUENCE OF BIOLOGIC AND SOIL FACTORS ON RANGELAND WATERSHED HYDROLOGY

(b) Bureau of Land Management.
(c) C. L. Hanson, Agric. Engr., Northwest Watershed Research Center, P. O. Box 2700, Boise, Idaho.
(d) Experimental, applied research.
(e) Investigate evaporative water losses from rangeland watersheds; develop mathematical models that describe evapotranspiration from rangeland watersheds; determine the relationships between soil-water changes and the associated watershed responses; and evaluate the effectsof range management practices on the hydrologic cycle. Approach will be to test both theoretical and empirical rangeland evapotranspiration models and incorporate the most suitable model into a general watershed mode. The model will be tested on data from four hydraulic lysimeters, a network of soil-water observation points, free-water surfaces, such as stock ponds, and individual watershed water balance studies; statistical methods and simulation models will be used to evaluate the effects of range management practices on rangeland watershed hydrology.
(g) A rangeland evapotranspiration model has been developed and tested. Soil water balance data are evaluated for effects of rangeland management systems.
(h) **Evapotranspiration Components of Watershed Models for the Great Plains,** D. A. Woolhiser, R. E. Smith, C. L. Hanson, *Evapotranspiration in the Great Plains Sem.*, Bushland, Tex., Mar. 23-25, 1970, *Res. Comm. Great Plains Agr. Council Pub.* **50**, pp. 111-136.
Response Units for Evaluating Performance of Rangeland Watersheds, C. B. England, G. R. Stephenson, *J. Hydrol.* **11**, pp. 89-97, 1970.
Model for Predicting Evapotranspiration from Native Rangelands in the Northern Great Plains, C. L. Hanson, *Ph.D. Dissertation*, Utah State Univ., Logan, 116 pages, 1973.
Soil Moisture Trends for Sagebrush Rangelands, W. J. Rawls, J. F. Zuzel, G. A. Schumaker, *Abstract, Proc. Amer. Geophs. Union Natl. Spring Mtg.* **54**, 4, p. 262, Washington, D. C., 1973.
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303-09317-820-00

GROUNDWATER IN RELATION TO MANAGEMENT OF RANGELAND WATERSHEDS IN THE NORTHWEST

(c) G. R. Stephenson, Geologist, Northwest Watershed Research Center, P. O. Box 2700, Boise, Idaho.
(d) Experimental, applied research.
(e) Delineate hydrogeologic boundaries, determine hydraulic properties, and recharge characteristics of groundwater flow systems; evaluate flow system response to management changes; determine cause-and-effect relationships between environmental parameters and chemical character of groundwater. Test and refine saturated and unsaturated flow models; determine physical parameters that influence the infiltration process. Determine flow system boundaries, aquifer properties, flow rates, and potential distribution by drilling, piezometer measurements, seismic surveys, and

pumping tests; obtain water samples for geochemical analyses; observe management practices to assess changes in physical and chemical properties of flow systems. Test unsaturated flow models by comparing results with field and laboratory data; use rainfall simulator-infiltrometer equipment on plots to determine infiltration rates and monitor movement of the moisture front; develop numerical solutions, simulating field tests, to define unsaturated hydraulic properties of soils.

(*g*) An infiltrometer study of several range sites has been completed. Procedures for utilizing low yield groundwater sources for rangeland water supplies has been installed. A subsurface flow model was tested and results published.

(*h*) **Solution of a Two-Dimensional, Steady-State Watershed Flow System: Part I. Description of Mathematical Model,** R. W. Jeppson, D. L. Schreiber, *Trans. ASAE* **15**, 3, pp. 457-463, 1972.

Solution of a Two-Dimensional, Steady-State Watershed Flow System: Part II. Evaluation by Field Data, D. L. Schreiber, R. W. Jeppson, G. R. Stephenson, C. W. Johnson, L. M. Cox, G. A. Schumaker, *Trans. ASAE* **15**, 3, pp. 464-470, 1972.

Stock-Water Development from Shallow Aquifer Systems on Southwest Idaho Rangeland, G. R. Stephenson, *Proc. Water-Animal Relat. Symp.*, Twin Falls, Idaho, June 26-28, 1973.

Mathematical Simulation of Subsurface Flow Contribution to Snowmelt Runoff. Reynolds Creek Watershed, Idaho., G. R. Stephenson, R. A. Freeze, *Water Resources Res.* **10**, 2, pp. 283-294, 1974.

303-09318-830-00

EFFECT OF RUNOFF, PRECIPITATION, CLIMATE, SOIL, VEGETATION, LAND USE AND LAND FORM ON SEDIMENT YIELD

(*b*) Bureau of Land Management.

(*c*) C. W. Johnson, Hydraulic Engineer, Northwest Watershed Research Center, P. O. Box 2700, Boise, Idaho.

(*d*) Experimental, applied research.

(*e*) Measure sediment yield and other water quality parameters and determine their relationships to snowmelt and rainfall runoff, soil and vegetation characteristics, land use, and topographic and physiographic features. Use existing ponds or construct appropriate catchments and devices to measure sediment yield and runoff from important sediment-contributing areas; determine chemical and biologic constituents in channel flow, irrigation return flow, and runoff from small feedlots; establish correlations between sediment yield and other physical parameters, using maps, surveys, and data from hydrologic networks and studies.

(*g*) Sediment sources and yields are being established for rangeland conditions. Water quality parameters are being measured and correlated with rangeland uses.

(*h*) **Sediment Yields from Small Rangeland Watersheds in Western South Dakota,** C. L. Hanson, H. G. Heinemann, A. R. Kuhlman, J. W. Neuberger, *J. Range Mangt.* **26**, 3, pp. 215-219, 1973.

303-09319-830-00

SELECTING A COMBINED WATERSHED RUNOFF-SOIL EROSION MODEL FOR THE NONIRRIGATED NORTHWEST

(*b*) Cooperative with Idaho University Agricultural Experiment Station.

(*c*) D. K. McCool, USDA, ARS, 215 Johnson Hall, Washington State University, Pullman, Wash. 99163.

(*d*) Experimental, theoretical, and field investigations; basic, applied, and developmental research; thesis.

(*e*) Existing watershed runoff models will be examined as to applicability for adequately describing runoff under Pacific Northwest conditions. Each watershed model will be assessed as to input requirements, applicability to small watersheds (10 to 500 acres), snowmelt component modeling, and suitability of outputs for potential erosion models. The potential erosion models will be most critically evaluated as to ability to distinguish between raindrop impact erosion and erosion resulting from overland flow. Promising models will be made operational on a computer and some tests as to adequacy for prediction purposes will be made using available data.

(*g*) Project is new and results are only tentative.

303-09320-830-00

CAUSATIVE FACTORS AND SYSTEMS FOR CONTROL OF EROSION IN THE PACIFIC NORTHWEST DRYLAND GRAIN GROWING REGION

(*b*) Cooperative with Washington State University Agricultural Experiment Station.

(*c*) D. K. McCool and R. I. Papendick, USDA, ARS, 215 Johnson Hall, Washington State Unviersity, Pullman, Wash. 99163.

(*d*) Experimental, theoretical, and field investigations; basic, applied, and developmental research.

(*e*) Use field studies to determine the quantitative effects of climatic influences, physiographic features, soil physical conditions, and agricultural land treatment on water-caused soil erosion. Develop from these data gross empirical models for short-term use in predicting soil loss on Palouse soils. Develop and test, in laboratory and field, combined hydrologic/erosion-sedimentation models to determine their usefulness in assessing the effect on soil erosion of proposed cultural treatments and mechanical systems.

(*g*) A first generation modification of the Wischmeier-Smith or Universal Soil Loss Equation has been developed from field soil loss data. The modified equation uses slope length and steepness relationships different from those used in the midwest as well as climatic hazard factor (equivalent erosion index) that includes the effects of snow melt runoff. The modified equation has been released for field trial.

(*h*) **Adapting the Universal Soil Loss Equation to the Pacific Northwest,** D. K. McCool, W. H. Wischmeier, L. C. Johnson, *ASAE Paper No. 74-2523.* Presented 1974 Winter Mtg. of ASAE. Copy of paper can be obtained from first author.

303-09321-840-00

INFILTRATION, EROSION CONTROL, AND SOIL WATER MOVEMENT IN RELATION TO IRRIGATION

(*b*) Cooperative with Washington State University College of Agriculture.

(*c*) David E. Miller, Research Soil Scientist, IAREC, Prosser, Wash. 99350.

(*d*) Field investigation; applied research.

(*e*) Investigate management systems for growing irrigated crops with minimum or trash tillage to improve infiltration rates and decrease wind and water erosion while maintaining yield and quality of crop. High frequency irrigation is being evaluated with emphasis on decreasing deep percolation and increasing water use efficiency. Time of deficit irrigation in relation to the desired crop product is considered.

(*g*) Furrow and sprinkler infiltration rates were increased and erosion decreased when plant residue was on the soil surface. With light, frequent irrigations, deep drainage losses were eliminated. Deficit irrigation of sugar beets did not decrease sugar yields on a loam soil nearly full of available water early in the irrigation season.

(*h*) **Soil Management to Reduce Runoff Under Center-Pivot Sprinkler Systems,** J. S. Aarstad, D. E. Miller, *J. Soil and Water Cons.* **28,** pp. 171-174, 1973.

Calculation of the Drainage Component of Soil Water Depletion, D. E. Miller, J. S. Aarstad, *Soil Sci.* **118,** pp. 11-15, 1974.

Effect of Daily Irrigation on Water Content and Suction Profiles in Soils of Three Textures, D. E. Miller. Accepted by *Soil Sci. Soc. Amer. Proc.*

Effect of Deficit Irrigation on Yield and Quality of Sugar Beets, D. E. Miller, J. S. Aarstad. (In review for submission to *Agron. Jour.*).

303-09322-820-00

TRAFFIC-SOIL COMPACTION-WATER INFILTRATION

(*c*) R. R. Allmaras, Soil Scientist, Columbia Plateau Conservation Research Center, Box 370, Pendleton, Oreg. 97801.
(*d*) Experimental, field investigation, applied research.
(*e*) Develop methods to evaluate the significance of soil compaction (traffic pans) on infiltration and water redistribution in soil subject to erosion during winter recharge. Field methods are used to evaluate hydraulic properties of the compacted soil, and also after physical rupture and chemical amendment. Predict effects of changed hydraulic properties on infiltration and distribution of water in soil. Evaluate treatments to maintain high water conductivity even after reconsolidation.
(*g*) Field evaluations are continuing. Results from earlier field measurements of hydraulic conductivity of compacted and mechanically ruptured soil layers now in progress.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION, Ogden, Utah 84401. Roger R. Bay, Director.

304-0363W-810-00

WATER QUALITY AND YIELD IN THE INTERMOUNTAIN AREA

See Water Resources Research Catalog **9**, 3.0335.

304-06969-810-00

SNOWPACK HYDROLOGY

(*c*) Mr. Harold F. Haupt, Project Leader, Forestry Sciences Laboratory, P. O. Box 469, 1221 South Main, Moscow, Idaho 83843.
(*d*) Field investigation, basic and applied research.
(*e*) Snowpack is being studied in northern Idaho for the applied objective of regulating yield and timing of streamflow. The particular research reported here pertains to improved instrumentation for measuring winter precipitation and estimated potential water yield as affected by slope exposure and early site recovery.
(*g*) There has been a need for a more precise determination of the input of rain and snowfall in windswept, mountainous terrain. The winter performance of three instruments: a standard weighing gage with horizontal orifice and windshield; a similar gage with modified (stereo) orifice and tilted windshield parallel to the slope inclination; and a dual-purpose net precipitation-snowmelt lysimeter were compared in openings and coniferous forests on the windward and lee side of a mountain ridge. Mounted on towers in windswept openings, the standard gage-horizontal shield and modified gage-tilted shield were less efficient than the ground-level lysimeter by 49 percent and 24 percent, respectively. On the lee side, protected in part from the full blast of wind, the lysimeter was seven to eight percent more efficient than the mounted gages. Due to these results, we purport that the lysimeter is superior to the mounted gage where wind movement is a major factor.
The hydrologic response of small clearcuts on north and south slopes in northern Idaho was investigated. On north slope, substantial gains (27 to 35 cm) in potential water yield per year accrued from removal of transpiring surfaces associated with plant cover, elimination of snow interception by a closed-canopied forest, perhaps some airborne movement of snow from the south (windward) to north (lee) slope, and slow reoccupation of the soil mantle by invading plant species. In contrast, on south slope there appeared to be no long-term gain in potential water yield resultant from timber cutting. Small differences in estimated yield between forest and small clearcut were evident in some years; in other years, none. Site factors with compensating effect were the cause. In the south-slope forest, water losses from interception were light because of the open-canopied structure of the timber, whereas in the small clearcut, water gains from reduced transpiration were more than used up by invading shrub species. We conclude that managing for increased water yield may be a valid consideration in the decision to log north but not south slopes similar to those studied.
A simple technique has been found to install soil moisture access tubes in stony or bouldery forest soils with a minimum of site disturbance. The hole for the access tube is made by driving a pointed, machine-tooled driving rod to the depth required with a specially constructed 15 kg king tube hammer. Under good soil conditions, 14 to 16 access tubes can be installed in a day, but when the soil is excessively bouldery, the number is reduced to five to seven. This method has the advantage of requiring substantially less capital outlay, causing less disturbance to surroundings and providing easier access to remote study areas than methods using large heavy equipment, such as tractor-borne hydraulic rams or jackhammers.
(*h*) **Improved Instrumentation for Measuring Melted Precipitation on Windswept Topography,** H. F. Haupt, *Proc. Symp. on Precipitation in Mountainous Areas*, p. 7385, Geilo, Norway, July 1972.

304-08436-810-00

FOREST PRACTICE EFFECTS

(*c*) Mr. Harold F. Haupt, Project Leader, Forestry Sciences Laboratory, P. O. Box 469, 1221 South Main, Moscow, Idaho 83843.
(*d*) Field investigation, basic and applied research.
(*e*) Forest practice studies on the impact of timber harvesting on the quality of stream water are presently in progress at several locations in northern Idaho. The monitoring program has a three-fold objective'to evaluate changes in the physical and chemical quality of stream water on and off clearcut-burned units; to characterize nutrient losses from different drainage patterns; and to determine the effectiveness of buffer strips in controlling sediment and nutrient losses.
(*g*) Three cutting units of varying size, soil, and aspect, located along streams in the Priest River Experimental Forest, were chosen for evaluation of changes in water quality caused by clearcutting and subsequent burning of slash. Water sampling stations were established on each creek – upstream, downstream, and on the site of the clearcut-burned areas. Except for onsite stations, buffer strips of natural vegetation were left along channels to minimize the effects of treatment. Physical and nutrient comparisons between the upstream and downstream stations showed slight increases in electrical conductivity, bicarbonate, sulfate, calcium, and magnesium. Similar comparisons between upstream and the onsite stations revealed significant increases in pH, electrical conductivity, turbidity, suspended solids, bicarbonate sulfate, potassium, calcium, and magnesium. Nutrients that did not indicate increases for buffer strip comparisons were chloride and sodium. In general, larger increases were observed at the onsite stations, except for one station with a different drainage pattern.

304-09323-830-00

TREE PLANTING FOR EROSION CONTROL ON GRANITIC ROADFILLS IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.
(*d*) Field investigations, applied research.
(*e*) Road erosion on road fill slopes is a major concern following road construction in the Idaho Batholith. The objectives of the present study were threefold, to measure the reduction in surface erosion following tree planting (ponderosa pine) with and without straw mulch; to provide information on tree survival and growth as affected

by mulches, fertilizer, and tree spacing; and to define some of the basic soil erosion processes that are acting on granitic roadfills. The study consists of 30 1/200-acre plots located on a large roadfill; four years of data are presently available for the analysis.

(*g*) Tree survival averaged about 97 percent for four years. Fertilizer increased tree height growth up to 95 percent during the year of peak effect. Tree planting, coupled with straw mulch and erosion netting, reduced surface erosion about 95 percent. Trees, alone, provided surprisingly large reductions in erosion, ranging from 32 to 51 percent. Daily erosion rates average higher during summer periods as compared to winter periods because of higher energy inputs. Dry creep is an important erosion process that accounts for about 20 percent of the total erosion occurring during summer periods.

(*h*) **Deep-Rooted Plants for Erosion Control on Granitic Road Fills in the Idaho Batholith,** W. E. Megahan, *Res. Paper INT-161*, Intermountain Forest and Range Exp. Sta., Forest Service, USDA, 22 pages, 1974.

304-09324-830-00

EFFECTS OF LOGGING AND ROAD CONSTRUCTION ON FORESTED WATERSHEDS IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Field investigation, applied research.

(*e*) First- and second-order drainages in forested areas have the potential for storing considerable sediment because of large volumes of debris in the channel (rocks, logs, etc.). Sediment storage information is required if realistic sediment yield simulation models for forested lands are to be developed. The design includes a detailed network of channel cross sections on seven study watersheds. Numerous data are collected to characterize channel conditions.

(*g*) Three years of data are available for analysis. Sediment storage during a low-flow year amounted to approximately 80 cubic feet per 100 lineal feet of channel (channel widths average about 3-feet wide). During a high-flow year, sediment storage dropped to approximately 40 cubic feet per 100 feet of channel.

304-09325-810-00

EFFECTS OF CLEARCUT LOGGING AND ROAD CONSTRUCTION ON SUBSURFACE FLOW IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Field investigation, applied research.

(*e*) Coarse-textured, relatively shallow soils; steep slopes; granitic bedrock with relatively low hydraulic conductivity; and large volume water inputs from snowmelt and/or large cyclonic storms are all conducive to the generation of subsurface flow. Road construction often incises the subsurface flow level, transforming subsurface to surface flow. This may interrupt the hydrologic function of the watershed containing the road, and has ecologic implications as well. Two micro-watersheds of 0.8 and 2.4 acres in size have been instrumented. Instrumentation includes a climatic station; snow lysimeters; a network of snow stakes, soil moisture access tubes and piezometers; and surface and subsurface flow measuring apparatus.

(*g*) No overland flow has been measured on either study watershed at any time. Subsurface flows occurred only during periods of large volume water inputs to the soils, and was restricted to the spring snowmelt periods. Maximum instantaneous peak flows have exceeded 20 cubic feet per second per square mile. Flows varied slightly between watersheds, but were vastly different between years. Yearly differences were related to amounts and rates of inflow. A comparison of nearby perennial watersheds suggests that the weathered and fractured granitic bedrock is more hydrologically active than previously thought. Interception of overland flow by roads is considerably greater than the flow generated by overland flow from the road surface itself.

304-09326-810-00

THE EFFECT OF LOGGING ON STREAMFLOW, SEDIMENT PRODUCTION, AND WATER CHEMISTRY IN THE SILVER CREEK STUDY AREA, IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Long-term laboratory and field investigation; basic research that will lead to prescriptions (practical applications) for land use management. Computer modeling of various land disturbances associated with logging and their off-site (downstream) effects is emphasized.

(*e*) Seven research watersheds treated in the southwestern Idaho Batholith have been monitored for a calibration period up to 15 years, including streamflow – quantity and regimen, sediment yield, water and sediment chemistry, and climate. Logging activities will commence in 1975 on a rigid, predetermined schedule to isolate single and multiple downstream effects of different logging systems (skyline and helicopter), differing cutting intensities (clearcut and select cut), and different attendant disturbances (roads vs. no roads; various slash disposal systems, etc.). The purpose of this project is to quantify off-site disturbances from advanced logging systems for future prediction.

(*g*) Accumulated baseline data on the undisturbed watersheds, including streamflow quantity and regimen; sediment production; water and sediment chemistry; and climatic data.

304-09327-390-00

SLOPE STABILITY OF PHOSPHATE MINE SPOIL DUMPS IN SOUTHEASTERN IDAHO

(*b*) Conducted in cooperation with College of Engineering, Utah State University, Logan, Utah.

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.

(*d*) Field and laboratory investigation, design and developmental research.

(*e*) With the development of large earth-moving equipment during the past decade, surface mining has increased very rapidly. Larger depths of overburden are being removed from above the ore mined. This overburden must be placed in spoil dumps, resulting in manmade fills, often involving considerably more cubic yardage than in large earth fill dams. The overburden removal may result in steep cuts to depths of hundreds of feet. In addition, earthen roads with widths comparable to super highways must be built for the heavy equipment to haul out the ore. All of these involve, in some form or another, the design, engineering, and placement of fills. Often these fills are given such cursory attention in the planning and construction phases that serious problems result from mass failures, massive erosion with heavy sediment loads carried by the runoff, and barren landscapes on which vegetation does not reestablish itself for many years – if at all.

Recognizing the existing conditions and potential future problems associated with slope stability of overburdened spoil dumps created during phosphate surface mining in southeastern Idaho, a study was undertaken to define and delineate, in general terms, the design and construction criteria for building spoil dumps in the steep terrain of the phosphate mines in southeastern Idaho which will be stable against massive structural failure and result in minimum surface erosion and movement.

(*g*) In summary, the internal friction angle of the materials tested indicates mass failure of the dump created from the overburden should not be subject to massive failure if placed on slopes of three to one or less, even under relatively adverse pore pressure conditions. If no pore pressures are permitted to develop, the dump fills might even

be stable if placed on steeper slopes up to 1.5 to 1. While the structural strength of the material is good (i.e., internal friction angles of 35° and above), it has low permeability and, consequently, is subject to high pore pressure if placed while at or near complete saturation. It will require about a year for pore pressures created in this manner to be dissipated.
The material contains relatively large amounts of silt-size grains, and, consequently, is susceptible to surface erosion. The material is also of the composition making it susceptible to frost action. With frost action loosening the surface material, its erodibility will be particularly great during the time of snowmelt and highest rainfall. The potential for large amounts of erosion during this season is great. Consequently, the slopes of the dump fills should be constructed taking into account the establishment of vegetation and minimization of erosion, as well as stabilizing against mass failure. Flatter slopes will generally be dictated by these latter considerations.

(*h*) **Slope Stability of Overburden Spoil Dumps from Surface Phosphate Mines in Southeastern Idaho,** R. W. Jeppson, R. W. Hill, C. E. Israelson, *Utah Water Res. Lab. Rept. RPWG 140-1*, 69 pages, April 1974.

304-09328-810-00

CHARACTERISTICS OF HIGH-INTENSITY RAINFALL IN THE INTERMOUNTAIN WEST

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan Utah 84321.
(*d*) Field and laboratory investigation, design and developmental research.
(*e*) Basic data for the intrastorm occurrence of high intensity rainfall bursts were obtained from precipitation records on the Davis County Experimental Watershed and the Great Basin Experimental Area. Analyses included intrastorm timing and number of rainfall bursts per storm, distribution of rainfall by increments of storm duration, and relation between depth of total storm rainfall and depth of burst rainfall. In addition, data were presented for four different design storms for storm return periods of 2 and 10 years.
(*f*) Completed.
(*g*) Storm arguments are presented for discontinuing the practice of using an annual series frequency analysis as a design aid for construction of forest roads or other control structures. Forest roads or control structures with an expected life of 25 years or less should be designed with the aid of a partial series frequency analysis of only those storms that contain high intensity rainfall bursts.
(*h*) **Some Intrastorm Characteristics of High Intensity Rainfall Bursts,** E. E. Farmer, J. E. Fletcher, in *Distribution of Precipitation in Mountainous Areas* **2**, *Geilo Symp.*, Norway, pp. 525-531, July 31-Aug. 5, 1972.

304-09329-820-00

ACCURACY OF NEUTRON SOIL MOISTURE MEASUREMENTS

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Applied laboratory research project.
(*e*) The effects of voids on the accuracy of neutron soil moisture measurements in coarse and fine sand were investigated, utilizing two 25-cubic foot plastic tanks. Test voids, three inches and six inches in diameter and 10 inches long, were cut from aluminum tubing and fastened to the neutron access tube in each tank. The difference in neutron measurements between the two tanks with the water at a given level measures the effects of the voids.
(*f*) Completed.
(*g*) A maximum error of +55 percent moisture by volume was caused by the large void in coarse sand with the void saturated; with the void drained, the error was -12.3 percent moisture. Errors in fine sand were slightly less than those in coarse sand; and errors due to the small void were about one-third the magnitude of errors due to the large void. Graphs were developed for use in estimating the size of voids adjacent to access tubes and in calculating the probable magnitude of measurement errors due to these voids when using field data.
(*h*) **Effects of Air Gaps and Saturated Voids on Accuracy of Neutron Moisture Measurements,** B. Z. Richardson, E. R. Burroughs, Jr., *Res. Paper INT-120*, Intermountain Forest and Range Experiment Station, Forest Service, USDA, 1972.

304-09330-810-00

EFFECTS OF LOGGING AND BURNING ON WATERSHED CHARACTERISTICS AND BEHAVIOR

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Applied field investigation.
(*e*) Sixty-five study units, from 10 to 58 acres in size, in the larch and Douglas-fir forest type of western Montana, were clearcut and the logging debris broadcast burned between 1967 and 1970. Multidisciplinary research on these units included the effects of these treatments on soil stability and runoff. Overland flow and sediment were caught in tanks below 24 runoff plots.
(*g*) Logging and burning temporarily impaired watershed protection and increased overland flow and erosion of soils that are derived from Belt series rocks and occur on gentle-to-steep slopes. However, vegetal recovery returned conditions to near prelogging status within four years. The small increase in plant nutrient losses, which occurred in the sediment and the overland flow during the denuded period, represented only a small fraction of the available nutrients on these sites. This strongly indicates that damage to soil and water resources and to the nutrient reservoir on these forest sites as a result of clearcut logging and burning is not serious from the standpoint of future site stability and productivity.
(*h*) **Plant Nutrient and Soil Losses in Overland Flow from Burned Forest Clearcuts,** N. V. DeByle, P. E. Packer, *Symp. on Watersheds in Transition, Amer. Water Res. Assoc. and Colorado State Univ. Proc.*, pp. 296-307, 1972.
Logging and Prescribed Burning Effects on the Hydrologic and Soil Stability Behavior of Larch – Douglas-Fir Forests in the Northern Rocky Mountains, P. E. Packer, *Proc. Fire and Land Management Symp.*, Univ. of Montana, Missoula, Oct. 1974.

304-09331-830-00

INHERENT ERODIBILITY OF IMPORTANT WESTERN MOUNTAIN SOILS

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Applied laboratory and field research.
(*e*) To a large degree, raindrops provide the detaching force that is prerequisite to the transport of soil particles by either flowing water or raindrop splash. Disturbed surface soil masses of three highly erodible soils, two coarse-granitic soils from the Idaho Batholith and one fine-textured clay soil from the Wasatch plateau in central Utah, were subjected to controlled simulated rainfall. The relative detachability of 11 soil-size fractions was determined by comparing the proportion of a given size fraction in the pretreatment soil mass with the proportion of that size fraction in the splashed soil.
(*f*) Completed.
(*g*) Tests were conducted under two levels of rainfall intensity, three degrees of slope steepness, and in the presence or absence of overland flow. Effects of differences in rainfall intensity and slope steepness were small. Overland flow had a pronounced effect in increasing particle detachment resulting from raindrop impact. The highest surface soil detachment hazard occurs in soils having high proportions of medium-sand-size material (particles and aggregates). This includes most of the better mountain soils in the western United States. Because particle detachability does not appear to be strongly affected either by slope steepness or by rainfall intensity, these detachability data probably can be generalized to many mountain slopes.

(*h*) **Relative Detachability of Soil Particles by Simulated Rainfall,** E. E. Farmer, *Proc. Soil Science Society of America* **37,** 4, July-Aug. 1973.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, NORTH CENTRAL FOREST EXPERIMENT STATION, Folwell Avenue, St. Paul, Minn. 55101. John H. Ohman, Director.

305-03887-810-00

WATERSHED MANAGEMENT RESEARCH IN NORTHERN MINNESOTA

(*c*) D. H. Boelter, USDA, Forest Service, North Central Forest Experiment Station, Grand Rapids, Minn. 55744.

(*d*) Experimental and field investigation; basic and applied research.

(*e*) Use basic hydrologic studies to develop management practices that will maintain or improve the quality and quantity of water yields from northern forest lands. Forest cultural practices (including timber harvesting, fertilization, use of herbicides, and prescribed burning) are studied to determine their effect on the water resources of northern conifer-hardwood forests. Of special concern will be the complex associations of uplands and bogs common to these forests. Methods will be developed for sampling and analyzing both surface and subsurface flows from treated areas. Wetland impoundments developed for wildlife habitat or cultural purposes will be monitored and management techniques developed to minimize their effect on water quality factors such as temperature and nutrient content. Sewage disposal on organic soil and adjacent upland sites will be tested to determine if these sites can be used for waste disposal without impairing the quality of the associated water resources.

(*g*) Complete clearcutting of aspen on the upland portion of an upland-bog watershed complex did not change the chemical composition of streamflow from the watershed in the first two years following completion of the clearcutting. Twenty-one different water quality parameters were measured. Total streamflow from the entire watershed increased 30 to 50 percent from June to October each of the first three years after cutting, but is expected to return to precutting levels in seven to eight years as the new vegetation is established.

Pipeline construction across forested wetlands often prevents the normal flow of water and results in forest damage unless adequate cross drainage is provided. Without adequate cross drainage the water table was found to be 0.7 to 0.9 feet higher on the upslope side of the pipeline and the swamp forest was killed. This damage was prevented when cross ditches at intervals of 150 feet were installed at the time of construction.

Maintaining the water table at depths of 0.3 and 0.6 meters in an organic soil resulted in 3.5 to 6.0 cm of subsidence, drying up of the sphagnum moss, and dominance of Labrador tea after 2-1/2 years. By contrast, with the water level maintained at the surface, the surface elevation rose 6.0 to 9.0 cm due to the rapid growth of the sphagnum mosses, and sedges and cotton grass were prominent. Evapotranspiration in the lower water level plots was estimated to be less than half of that in the high water level plots due primarily to the reduced evaporation of the sphagnum mosses.

The effectiveness of drainage in organic soils varies with the hydraulic conductivity of the peat materials through which the water must flow. An open ditch hastened the drainage of water from surface or near surface horizons of fibric (moss) peat on a typical lake-filled organic soil. However, it had little influence on the water table beyond 5 m from the ditch when the water table was in deeper horizons of moderately decomposed (hemic) peat. In an organic soil with less decomposed (fibric) peat throughout several meters depth at the surface a similar ditch influenced water table as far as 50 m from the ditch.

(*h*) **Water Table Drawdown Around an Open Ditch in Organic Soils,** D. H. Boetler, *J. Hydrol.* **15,** pp. 329-340, 1972.

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305-03889-810-00

WATERSHED MANAGEMENT RESEARCH IN THE DRIFTLESS AREA OF SOUTHWESTERN WISCONSIN

(*b*) Some aspects of project in cooperation with Wisconsin Department of Natural Resources and Department of the Army.

(*c*) Richard S. Sartz, USDA, Forest Service, North Central Forest Experiment Station, La Crosse, Wis. 54601.

(*d*) Field investigations; basic and applied research.

(*e*) Research was conducted on the influence of both natural and planted forests on runoff and erosion (particularly with regard to spring-thaw floods) and hydrologic effects of soil freezing. This research will be completed in 1975. Major emphasis of the project is now on wintertime land disposal of waste water.

(*g*) Soil water depletion by cut and uncut forest on a north slope was measured for three years with a neutron meter. Depletion by the uncut forest began early in the growing

season at all depths measured and continued at a nearly constant rate until leaf fall. Seasonal depletion in a 1.5 m soil mantle averaged 188 mm on uncut plots, 87 mm on clearcut plots, and 57 mm on plots without vegetation. The amount of depletion increased with mantle depth; thus cutting had a greater water-saving effect on deeper soils. Estimates of evapotranspiration by uncut forest agreed closely with empirical estimates of potential evapotranspiration.

Aspect affects soil frost depth by influencing the amount of solar radiation received at the ground or snow surface. Depending on the conditions, frost can be of equal depth on north and south slopes, deeper on north slopes, or deeper on south slopes. Data illustrate all three conditions.

Depth of soil freezing and overland flow were measured under four hardwood forest conditions in southwestern Wisconsin'woody vegetation cut and removed; all vegetation cut and removed; uncut forest with litter removed; and undisturbed forest. Removing only the litter and removing all the vegetation increased both soil freezing depth and overland flow. Removing only the woody vegetation decreased both. Frost-depth means in a year of deep frost were 6 and 11 cm on the woody vegetation removed and undisturbed plots, and 19 and 35 cm on the all vegetation-removed and litter-removed plots. Overland flow values ranged from less than 1 cm on the woody vegetation-removed plots to more than 7 cm on the all vegetation-removed and litter-removed plots. The increases in frost depth and overland flow appeared to be related to changes in soil bulk density and porosity.

Storm runoff from two small open pasture watersheds was measured for 11 years; during the first seven years both were grazed, and during the last four years only one was grazed. Their runoff behavior was similar when both were grazed, but by the third year after cessation of grazing, runoff from the ungrazed watershed had dropped sharply. The ungrazed/grazed ratio for mean total flow had dropped from 1.17 to 0.10 and for mean peak flow from 0.82 to 0.03. After three years without grazing a heavy mat of bluegrass blanketed the ground, and soil bulk density was significantly lower.

(*h*) **Soil Water Depletion by a Hardwood Forest in Southwestern Wisconsin,** R. S. Sartz, *Soil Sci. Soc. Am. Proc.* **36**, pp. 961-964, 1972.

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305-09332-870-00

SEWAGE DISPOSAL ON FOREST AND ASSOCIATED LANDS

(*b*) Some aspects of project are in cooperation with Michigan Department of Natural Resources.

(*c*) Dean H. Urie, USDA, Forest Service, North Central Forest Experiment Station, P. O. Box 632 - 131 North, Cadillac, Mich. 49601.

(*d*) Field investigations, basic and applied research.

(*e*) Research is conducted on the environmental impact of application of municipal and industrial sewage wastes to forest lands. Studies are primarily concerned with nitrate pollution hazards to groundwater under irrigation of natural and planted short rotation forest types, under irrigation with sewage lagoon effluents and with municipal and pulp and paper sewage sludges. An associated problem is the field and laboratory investigation of the use of sewage sludge for rehabilitation of acid strip-mine spoil. Continuing studies include investigations on the effects of different size sediment loads (primarily sand bedloads) on trout populations, development of techniques to reduce bedload, and effects of strip-cutting and clearcutting conifer plantations on groundwater yields and snowpack accumulation.

(*g*) Three seasons of irrigation with sewage effluent have shown that 60-80 percent of the nitrogen does not pass the 60 cm depth in a *Pinus resinosa* plantation. Boron concentrations in foliage exceeded 70 ppm by the end of the second growing season, causing some flaring but not reducing needle length or dry weight. Sludge rates at 150 and 300 dry tons per acre reduced the acidity and metal content of leachate from 120 cm deep leaching chambers filled with acid spoil bank materials. Nitrate levels in the leachate rose rapidly after two years to peaks of 200-400 ppm NO_3-N. Injection of campground sewage into a Kalkaska soil resulted in maximum NO_3-N levels in groundwater of 40 ppm in a field test where the water table was 1.8 to 2.6 m and 4 ppm where the water table was 3.6 m. No bacterial pollution of groundwater was detected under natural precipitation.

Laboratory and field tests on ceramic soil-water samplers showed that the samplers collected questionable data in the unsaturated zone. A smaller version of the sampler was designed which minimized some of the problems. An entirely different approach was used in the development of the "groundwater profile sampler" – an instrument to collect discrete water samples at predetermined depths in an aquifer.

Difficult-to-measure moving sand bedload can be sampled with a DH-48 sediment sampler at sills installed in the streambed. Bedload can be trapped and removed by excavating sedimentation basins in the streambed. Sediment had little effect on trout egg survival in one Michigan stream, however, variations in groundwater inflow had significant effects on egg hatching dates.

(*h*) **Phosphorus and Nitrate Levels in Groundwater as Related to Irrigation of Jack Pine with Sewage Effluent,** D. H. Urie, in *Recycling Treated Municipal Wastewater and Sludge Through Forest and Croplands*, pp. 166-183, 1973, ed. W. E. Sopper, L. T. Kardos, Penn. State University.

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306-0242W-810-00

MAINTAINING WATER QUALITY AND INCREASING SUMMER STREAMFLOW IN NEW ENGLAND HARDWOOD ECOSYSTEMS (Durham, N. H.)

(*e*) See Water Resources Research Catalog **6,** 3.0334.

306-0243W-810-00

PROTECTING WATER QUALITY AND IMPROVING WATER YIELDS FROM FORESTED LAND IN THE CENTRAL APPALACHIANS (Parsons, W. Va.)

(*e*) See Water Resources Research Catalog **8,** 3.0357.

306-09333-890-00

REDUCTION IN SURFACE-MINING DAMAGES TO FOREST RESOURCES BY IMPROVING MINING PROCEDURES AND REHABILITATION MEASURES (Berea, Ky.)

(*d*) Field investigations, basic and applied research.
(*e*) Streamflow and water quality are being measured on a number of small watersheds in eastern Kentucky and in West Virginia in order to document the effects of surface mining for coal on the water resources (see WRRC **6,** 5.0561).
(*g*) The disposition of moisture in strip-mine spoil in relation to grading compaction is important to the successful establishment of a vegetative cover. A study of subsurface moisture and density on a graded spoil on an area type mining operation showed "valley" sites to be about 20 lb/ft^3 less dense than the "ridge" sites. Except for the surface layer there was more moisture available to plants in the "valley" areas. Ridge and valley locations refer to topography of spoil prior to grading. Indications are that deep-rooted plants may be better adapted to spoil environments than shallow-rooted species. Data from six watersheds show that stream turbidity and peak flows increase during mining but turbidity returns to near pre-mining levels within six months or so. Total dissolved solids content of streamflow increases significantly. Measurements of sediment accumulation in debris basins below surface-mined lands in eastern Kentucky show highest sediment yield during the first six months after mining. The erosion rate diminishes to fairly low levels within three years. Methods of mining and spoil handling techniques affect sediment yield as does the rapidity of establishment of a vegetative cover.
(*h*) **Moisture and Density Relations on Graded Strip-Mine Spoils,** W. R. Curtis, in *Ecology and Reclamation of Devastated Land* **I**, pp. 135-144, J. Hutnik and Grant Davis (ed.), Gordon and Breach, N. Y., 1973.
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306-09334-810-00

AMENITIES DERIVED FROM TREES, AND MULTIPLE-USE MANAGEMENT OF MUNICIPAL WATERSHEDS (Pennington, N. J.)

(*c*) Edward S. Corbett, Principal Hydrologist, P. O. Box 115, Pennington, N. J. 08534.
(*d*) Field investigations; basic and applied research.
(*e*) The forested watersheds of Megalopolis are a major water-producing area. A recent survey of Northeastern Municipal Watersheds showed that two million acres of forest land are controlled and managed primarily for municipal water supplies. Major problem areas are water quality control, recreational use of municipal watersheds, and water yield improvement. Studies underway include the effects of vegetation type conversions on water quality and quantity; nutrient budgets; relative water use by overstory and understory vegetation; partial area hydrology; developing a fundamental understanding of hydrologic system linkages to assist in optimizing management objectives; developing guidelines for integrating uses such as production of quality water, recreation, aesthetics, timber and wildlife on municipal watersheds; and the disposal of waste water in woodlands. A substantial portion of the research is conducted in conjunction with municipal and state agencies, universities and the Pinchot Consortium for Environmental Forestry Studies.
(*g*) Gypsy moth defoliation caused a 5.4 inch increase in water yield (146,000 gallons per acre) on an experimental municipal watershed in northern New Jersey on which 75 percent of the overstory leaves had been destroyed. The trees put forth a second crop of leaves at the end of the summer following heavy rains in late August. Deadening overstory vegetation (oak-hickory) on another experimental watershed with herbicides resulted in a 7.8 inch increase in water yield. There was no contamination of streamflow by the herbicide. Four years later this water yield increase had been reduced by 55 percent in response to vegetation regrowth. The number of low flow days (stream discharge less than 0.1 csm) was considerably reduced. Many municipal watershed managers have improved the quality of their raw water supply by reforesting abandoned and eroding lands. Part of the cost paid for this improvement is the reduction in water yielded from these areas. A study on a Maryland municipal watershed indicated that converting an open land watershed to a young pine forest caused a decline in water yield of 238,000 gallons of water per year per acre reforested.
(*h*) **Effects of Management Practices on Water Quality and Quantity – Newark, New Jersey Municipal Watersheds,** E. S. Corbett, J. H. Heilman, *Municipal Watershed Management Symp. Proc., USDA For. Serv. Gen. Tech. Rept. NE-13*, 1975.
Effects of Management Practices on Water Quality and Quantity – Baltimore, Maryland Municipal Watersheds, E. S. Corbett, W. Spencer, *Municipal Watershed Management Symp. Proc., USDA For. Serv. Gen. Tech. Rept. NE-13*, 1975.
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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT

STATION, P. O. Box 3141, Portland, Oreg. 97208. Robert E. Buckman, Director.

307-04757-810-00

WATER YIELD AND EROSION, WENATCHEE, WASHINGTON

(*c*) Dr. A. R. Tiedemann, Project Leader.
(*d*) Field investigations; basic and applied research.
(*e*) Generate information necessary to develop prescriptions which improve or enhance quantity and timing of water yield without decreasing water quality; reduce erosion and restore land stability and productivity; and rehabilitate deteriorated sites in the mid-Columbia River Basin forests of eastern Oregon and Washington. Studies related to erosion reduction include characteristics of soil related to erodibility; effects of climate, vegetation and parent material on soil development, soil movement such as creep or mass movement, characteristics of forest humus types; and physical control of erosion by increasing plant density of vegetation. Studies related to water quantity and quality include changes in volume and timing of runoff, water chemistry and water temperature following timber harvest, wildfire or defoliation by insects; changes in wind patterns, soil moisture use, and snow accumulation and melt following common silvicultural practices; and water use rates by common tree species within the study area.
(*g*) Annual water yield increased 3.5 inches (50 percent) and maximum daily stream temperature increased 10° F the first year after three experimental watersheds in North-Central Washington were burned by wildfire.

Vegetation, soils, climate, and animal populations of the Meeks Table Natural Area were described. The area, located on the eastern slopes of the Washington Cascades, is an isolated flat-topped butte typical of nearby basalt-capped plateaus.

A study of winter sports areas resulted in recommendations to prevent erosion on these fragile sites. When these recommendations were followed, a ski area near Wenatchee, Washington, was successfully stabilized.

Erosion control seeding on burned watersheds in North Central Washington increased first-year vegetative cover by up to one-third. Orchard grass, hard fescue, and timothy provided most of the first-year cover. Fertilization with urea or with ammonium sulfate did not improve cover but it did improve vigor of seeded species.

Nitrate-nitrogen increased from 0.005 parts per million (ppm) in a control stream to 0.042 ppm in a stream from a burned watershed and to 0.310 ppm in a stream from a burned and urea-fertilized watershed. Neither burning nor urea fertilization caused increases in nitrogenous constituents to levels above recommended values for municipal water supplies.

Analysis of climatic records from the Columbia Basin in Central Washington indicated no significant changes in July-August precipitation or air temperature following large-scale irrigation. However, open-pan evaporation tended to decrease as irrigated area expanded.

A summary of rainfall interception by conifers of North America indicated similar values for canopy interception loss between pine species. However, canopy interception loss was much greater in stands of fir, spruce, and hemlock.

Forest and range soils on Swauk Sandstone have a relatively low inherent erodibility, but surface erosion is evident in some places, probably reflecting past land use practices. Protective ground cover is the most effective management method to maintain adequate infiltration and to prevent erosion.

Ring width of sagebrush plants growing in the Columbia Basin was correlated with annual precipitation. These results can be used to extend precipitation records to ungaged areas.

Wildfire followed by excessive precipitation amounts caused extensive damage to watersheds in North-Central Washington. Stream gaging stations on two experimental watersheds were destroyed by debris flows. Water yeild, water temperature, and effectiveness of erosion control measures are discussed.

A pot study indicated that stomatal closure of lodgepole pine, ponderosa pine, and Engelmann spruce seedlings occurs at lower soil-water potential than fir or Douglas-fir seedlings. The management implication is that water use should be greatest by the firs because they continue to extract water at higher moisture potentials.

(*h*) **First-Year Effects of Wildfire on Water Yield and Stream Temperature in North-Central Washington,** J. D. Helvey, *Proc. Symp. Watersheds in Transition*, Fort Collins, Colo., June 19-22, 1972. *Amer. Water Resour. Assn. and Colo. State Univ. Proc. Ser. 14*, pp. 308-312, illus., 1972.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT

STATION, P. O. Box 245, 1960 Addison Street, Berkeley, Calif. 94701. Robert W. Harris, Director.

308-04996-810-00

WATER YIELD IMPROVEMENT, CONIFER ZONE

(*b*) Cooperative with U. S. Geologic Survey, U. S. Bureau Reclamation, National Aeronautics and Space Administration and Univ. California.
(*c*) Dr. James L. Smith, Project Leader, Water Yield Improvement, Conifer Zone.
(*d*) Experimental; field investigation; basic and applied research.
(*e*) Determine the relationships which exist between the climate and the snowpacks of the Sierra Nevada, and how these relationships are affected by the presence or absence of forest cover, so that the effect of forest cultural practices upon snow metamorphism and melt may be predicted in advance of application of such practices. Present studies emphasize study of snow density changes, water holding capacities, snow metamporphism and melt rates under a variety of meteorological and cover conditions, and the effect of these changes upon timing of delivery of water to streams.
(*g*) Study of snowpacks under open and forested conditions on a variety of aspects has documented some of the fundamental physical laws governing the hydrology of the "warm" snowpacks of the Sierra Nevada and Cascade Mountain Ranges. A new concept about snow accumulation and melt and the effects of aspect and cover has been developed and published. It has been determined that snow accumulates differentially under stiff branched tree species than under those having cylindrically shaped crowns with flexible boughs. Harvest of each type will have different effects upon water yield and time of snow melt.

A new study employing lysimeters will investigate evaporation reduction and effect upon snow hydrology of application of an evaporation suppressant to snowpacks.

Equipment for in-situ measurements of free-water content has been developed and is undergoing testing.

Soil temperature under snow cover has been found to have negligible effect upon snow melt because of the large and frequent snow melts occurring throughout the snow season. These keep the soil at the freezing point.

A series of shadow length tables has been prepared and is available with which the shadow length for a combination of slopes, aspects and dates may be determined. These cover the contiquous United States. With these tables land managers may determine the size forest opening to make to keep the sun out or to admit it into forest situations to retard or hasten snow melt.

(*h*) **Forest Soils and the Associated Soil - Plant Water Regime,** J. L. Smith, in *Isotopes and Radiation in Soil – Plant Relationships Including Forestry*, Intl. Atomic Energy Agency, Vienna, Austria, 1972.

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308-04997-810-00

HYDROLOGIC PROCESSES, MOUNTAIN WATERSHEDS

(*c*) Mr. Henry W. Anderson, Work Unit Leader.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Through analytical modeling to advance the state of knowledge of watershed hydrology and sedimentation, and particularly, knowledge of the relationship of watershed management and other hydrologic processes at the water sources to water yield, floods, sedimentation, and water quality delivered from wildland watersheds.
(*g*) Analysis of "years to return to normality" was made for 10 northern California watersheds, following the accelerations in average sediment concentration associated with the December 1964 flood. Returns to normalcy took from zero to nine years, with the rate of decline being related both to the amount of initial acceleration and watershed differences. Explained variance in years to recovery was 85 percent and the standard error of estimate was 1.2 years. Years to recovery increased with the area of poor logging, with the area of steep grassland, with the percent of area in the sedimentary rock types Cenozoic or younger, and with the coefficient of path lengths in the watershed. Thus part of the delayed recovery was attributed to sediment in transit released by the major flood and part to recovery of sediment source areas from the impact of the floods. Sediment determinations made during post-flood periods, if unadjusted, may be in error by a factor of two or more. To provide a basis for improved estimates of precipitation in mountain areas, the relation of mean annual streamflow to topography was determined from data for 14 watersheds on the lee side of the Sierra Nevada of California. Variables indexing effects of rise, air flow separation, spillover, and barrier height explained 99 percent of the variance; standard error was 11 percent. Streamflow increased for the area 8 km to the lee of the Sierra Nevada ridge, and was maximum at about 2700 m. The relations were tested using snow course data during periods with snow only.

In California almost all good reservoir sites have been taken, so prevention of loss of capacity of present reservoirs is important. Reservoir deposition measurements in 43 northern California reservoirs with catchment areas greater than five square kilometers were quantitatively related to watershed, streamflow, snowiness, and land use variables, including 10 different classes of roads. Streamside location of roads was the greatest contributor to sedimentation, twice that of other locations, with improved secondary roads near streams being the greatest contributor. The differences in sedimentation associated with roads gives planners a quantitative basis for decision among alternative locations and design of roads in forest areas.

(*h*) **Major Floods, Poor Land Use Delay Return of Sedimentation to Normal Rates,** H. W. Anderson, *USDA Forest Serv. Res. Note PSW-268*, 4 pages, 1972.

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308-04998-810-00

PARAMETERS AFFECTING MANAGEMENT OF FORESTS ON UNSTABLE LANDS

(*b*) Cooperative with California Div. of Forestry and Humboldt State College.

(*c*) Dr. Raymond M. Rice, Project Leader, Pacific Southwest Forest and Range Experiment Station, 1550 B Street, Arcata, Calif. 95521.

(*d*) Experimental; field investigations; basic and applied research.

(*e*) The Unit's mission is to gain an understanding of the hydrological and biological processes of the ecosystems of the north coast and Klamath Mountains of northern California and southern Oregon; and to develop information needed for integrated resource management consistent with protecting the resources and environment on unstable lands. Initially, the major thrust of research will be directed at problems associated with forest management on steep granitic terrain. This limited scope was chosen because it appeared to be within the capabilities of the research work unit, reflected serious current management problems on several national forests, and because characteristic failures are debris avalanches which may be more easily related to vegetative manipulation than other types of mass movements. Studies underway will attempt to define the decline and recovery of slope strength that accompanies root decay following timber harvest and subsequent regeneration. A system is being developed to predict the probability of landslide occurrence on granitic terrain based on site characteristics. Silvicultural studies will focus on ways of insuring slope stength recovery through rapid stocking with timber species. Studies of moisture stress as a function of crown density will be used to appraise the severity of planting sites. Variations in planting stock, planting methodology, fertilizer application, and overstory will be investigated to determine how best to use regeneration to maintain stability or rehabilitate landslide scarps.

(*g*) Preliminary investigations on the English Peak batholith found landslides restricted, almost exclusively, to areas where only a modest amount of weathering had taken place. Apparently, there is a vulnerable stage in soil development after the strength of the original rock matrix is gone and before sufficient clay has developed to give cohesion to the soil. In addition to the weathering variability within batholiths, comparison of soil data from the English Peak batholith with that from the Tish Tang batholith suggest that there may be a large variability between batholiths as well. Preliminary results from an investigation of root strength of Douglas fir showed little decline in strength for the first two years after cutting followed by a rapid loss of strength beginning after the second post-logging year. After six years, very few old roots less than 5 mm in diameter were found. After 11 years, almost no old roots less than 50 mm in diameter are intact. However, during the period from six to 11 years there was a rapid development of brush roots (Ceanothus veluntinus). The first-year results of a study on the effect of crown cover on planted regeneration of Douglas fir found the best height growth by 10 year old trees was achieved on south-facing slopes. However, these slopes were severely understocked due to heavy mortality of planted stock and complete absence of any natural regeneration. The density of competing brush species changed little under all residual crown densities and on both north and south slopes. It is hypothesized that the slower development of trees on north slopes may be due to the maximum growth taking place later in the season than on the south facing slopes. It is felt that competition from brush may be more effective in suppressing tree growth when the moisture stress is higher later in the season. Preliminary analyses of the variance of suspended sediment samples suggest that the permissible increase in sediment in the regulations of some western states may be statistically undetectable.

(*h*) **Road Construction on Caspar Creek Watersheds – 10-Year Report on Impact,** J. S. Krammes, D. M. Burns, *USDA Forest Serv. Res. Paper PSW-93*, Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif., illus., 10 pages.

308-04999-810-00

FLOOD AND SEDIMENT REDUCTION FROM STEEP UNSTABLE BRUSHLAND OF THE SOUTHWEST

(*b*) Cooperative with California Div. of Forestry, Univ. of California, Los Angeles.

(*c*) C. Eugene Conrad, Actg. Project Leader, Pacific Southwest Forest and Range Expmt. Sta., 110 North Wabash Ave., Glendora, Calif. 91740.

(*d*) Experimental; field investigations; basic and applied research.

(*e*) To gain an understanding of the runoff and erosion processes of steep, unstable chaparral watersheds and their contribution to downstream floods and sedimentation, and to develop effective land management practices to combat excessive runoff and erosion, both as emergency measures following fires and as a means of establishing long-term environmental stability.

(*g*) Water-repellent soils, produced when hydrophobic organic substances coat mineral soil particles, are associated with increased runoff and erosion and decreased success in establishing plants on burned forest areas. The water drop test indicated intense water repellency when the drop evaporates before penetrating the soil layer. Intense water repellency was detected using the water drop test on a soil layer between 2.5 and 7.6 cm below the soil surface following a light burn in a lodgepole pine forest in Oregon. Intense water repellency was detected in a soil layer between 6.4 and 15.2 cm below the surface in a nearby lodgepole pine stand that was severely burned. The depth and severity of water repellency can easily be determined on burned forest sites using the water drop test and based on these data land managers can improve their predictions of erosion, sedimentation, and plant community reestablishment problems. The depth and severity of water repellency after fire also appears to be related to the amount of water contained in the soil underlying an area burned. Laboratory tests using pine litter over wet and dry sand showed that less water repellency developed in the wet sand during a burning experiment. The heat pulse used to generate the water repellency in the sand was the same as found during controlled burns or wildfires in natural conditions. The results from these laboratory tests suggest that land managers using controlled burning as a management tool could minimize problems of water repellency by burning when soil moisture is high.

(*h*) **Burning Trials in Shrubby Vegetation Desiccated with Herbicides,** J. R. Bentley, C. E. Conrad, H. E. Schimke, *USDA Forest Serv. Res. Note PSW-241*, Pacific SW Forest and Range Expmt. Sta., Berkeley, Calif., 9 pages, illus., 1971.

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308-07000-810-00

WATERSHED SYSTEMS DEVELOPMENT AND APPLICATION UNIT

(*b*) Watershed Management, U. S. Forest Service, National Forest System.
(*c*) Lloyd J. Lundeen, Project Leader, Watershed Systems Development and Application Unit.
(*d*) Theoretical; developmental, basic and applied research.
(*e*) Development of a systems approach to the resource management of National Forest land; and the development of analysis tools through the use of computers to solve day-to-day, on the ground problems in watershed and natural resource management.
Provide consulting, training, and computer analysis services to the water and land managers of the National Forest System. Resource analysis tools are developed, and watershed management research results are blended with the water and related resource problems of the land manager.
(*g*) Since the formation of this work unit in 1966, about 60 computer programs are operational to reduce streamflow, precipitation, temperature, wind movement, etc., data and to analyze hydrometeorological data for determining water balances, erosion and sedimentation amounts, etc. These programs have been designed for and are particularly useful to water resource managers in the National Forest System. The unit recently completed an operational version of an analytical system called the Resource Capability System. The purpose of this system is to assist decision makers in evaluating alternative uses of forest and related lands. A user's guide is available which outlines a systems approach to resource management. Operations research tools such as linear programming, simulation techniques for the analysis of hydrologic information and the necessary supporting programs are currently operational.
(*h*) **The Practical Linkage of Economics with Hydrologic Data and Interpretations for Use in the Resource Planning/Decision Making Process,** R. D. Dyrland, *1st Applied Wildland Watershed Management Workshop Proc.*, Grand Targhee, Idaho, pp. 29-35, Feb. 1974.
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308-09335-810-00

FOREST AND WATERSHED RESOURCE MANAGEMENT RESEARCH IN HAWAII AND OTHER PACIFIC ISLAND AREAS

(*b*) Cooperative with Hawaii Department of Land and Natural Resources and University of Hawaii.
(*c*) Robert E. Nelson, Project Leader, Forestry Research, Hawaii.
(*d*) Experimental; field investigations; basic and applied research.
(*e*) Research on effects of land use on watershed hydrology; effects of vegetation types on soil hydrology; stream sediment relationships to watershed vegetation cover; and water infiltration measurement systems.
(*g*) Water infiltration capacities are significantly greater for soils under forest cover than under cultivation or grazing.
(*h*) Publications available from Institute of Pacific Islands Forestry, 1179 Punchbowl Street, Honolulu, Hawaii 96813:
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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, 240 W. Prospect Street, Fort Collins, Colo. 80521. Karl F. Wenger, Director.

309-0074W-810-00

WATERSHED MANAGEMENT RESEARCH (CHAPARRAL), TEMPE, ARIZONA

(*c*) J. Robert Thompson, Project Leader, Forest Hydrology Laboratory, Arizona State University.
(*e*) See Water Resources Research Catalog.
(*h*) **Increases in Streamflow After Converting Chaparral to Grass,** A. R. Hibbert, *Water Resour. Res.* **7**, pp. 71-80, 1971.
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309-02658-810-00

WATER YIELD IMPROVEMENT IN THE BLACK HILLS, RAPID CITY, SOUTH DAKOTA

(*c*) Ardell J. Bjugstad, Project Leader, Forest Research Laboratory, South Dakota School of Mines and Technology.
(*d*) Experimental; basic and applied research.
(*e*) Determine geologic, geomorphic, and forest factors that influence or relate to quantity and timing of the water yield.
(*h*) **The Black Hills (South Dakota) Flood of June 1972: Impacts and Implications,** H. K. Orr, *USDA Gen. Tech. Rep. RM-2*, 12 pages, 1973.
Morphometry of Three Small Watersheds, Black Hills, South Dakota, and Some Hydrologic Implications.

Water Yield Characteristics of Three Small Watersheds in the Black Hills of South Dakota, H. K. Orr, T. Vander Heide, *USDA For. Serv. Res. Paper RM-100*, 8 pages, 1973.

309-03569-810-00

WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING

(*b*) Laboratory project and Bureau of Land Management.
(*d*) Field investigation; applied research.
(*e*) Water yield characteristics of big-sagebrush lands are being studied on plots and gaged watersheds, and hydrologic effects of control measures are being determined. Methods for increasing snow accumulation in windswept areas are also being developed and tested.
(*h*) **Evaporation Losses of Windblown Snow, and the Potential for Recovery,** R. D. Tabler, *Proc. West. Snow Conf.* **41**, pp. 75-79, Grand Junction, Colo., Apr. 1973.
New Snow Fence Design Controls Drifts, Improves Visibility, Reduces Road Ice, R. D. Tabler, *Proc. Ann. Transp. Eng. Conf.* **46**, pp. 16-27, Denver, Colo., Feb. 1973.
Weather Conditions That Determine Snow Transport Distances at a Site in Wyoming, R. D. Tabler, R. A. Schmidt, in *The Role of Snow and Ice in Hydrology. Proc. Symp. on Properties and Processes* (*UNESCO*), Banff, Alberta, Can., 9 Sept. 1972. 2 vols., pp. 118-126, 1973.
Soil Moisture Response to Spraying Big Sagebrush the Year of Treatment, D. L. Sturges, *J. Range Mngmt.* **26**, pp. 444-447, 1973.

309-03895-810-00

WATER YIELD IMPROVEMENT IN ALPINE AREAS AND AVALANCHE PREDICTION AND PREVENTION

(*d*) Experimental and field investigation; applied research.
(*e*) Determine methods for controlling the deposition of snow in alpine areas in order to increase summer streamflow from late-lying snowfields. To reduce danger from snow avalanche to winter sports areas, highways, mining operation, and homes by improving the evaluation and forecasting of avalanche hazard and developing methods of stabilizing the snow cover on mountain slopes.
(*h*) **Predicting Avalanche Intensity from Weather Data: A Statistical Analysis,** A. Judson, B. J. Erickson, *USDA For. Serv. Res. Paper RM-112*, 12 pages, 1973.
Physical Properties of Alpine Snow as Related to Weather and Avalanche Conditions, M. Martinelli, Jr., *USDA For. Serv. Res. Paper RM-64*, 35 pages, 1971.
Snow Fences for Influencing Snow Accumulation, M. Martinelli, Jr., in *The Role of Snow and Ice in Hydrology, Proc. Symp. on Measurement and Forecasting* (*WMO*)2 vols., pp. 1394-1398, 1973, Banff, Alberta, Can., Sept. 1972.
The Bulk Tensile Strength of Snow, R. A. Sommerfeld, *Amer. Geophys. Union Trans.* **52**, p. 825 (Abstract), 1971.
The Relationship Between Density and Tensile Strength in Snow, R. A. Sommerfeld, *J. Glaciol.* **10**, pp. 357-362, 1971.
Statistical Problems in Snow Mechanics, R. A. Sommerfeld, in *Advances in North American Avalanche Technology'1972 Symposium*, pp. 29-36. *USDA For. Serv. Gen. Tech. Report RM-3*, 54 pages, 1973.
The Classification of Snow Metamorphism, R. A. Sommerfeld, E. La Chapelle, *J. Glaciol.* **9**, pp. 3-17, 1970.
A Centrifugal Tensile Tester for Snow, R. A. Sommerfeld, F. Wolfe, Jr., *USDA For. Serv. Res. Note RM-227*, 4 pages, 1972.
Sublimation of Wind Transported Snow – A Model, R. A. Schmidt, Jr., *USDA For. Serv. Res. Paper RM-90*, 24 pages, 1972.
Generalization of Heefeli's Creep-Angle Analysis, R. I. Perla, *J. Glaciol.* **11**, pp. 447-450, 1972.
Hyperbolic Stress Equations for Compressible Slabs, R. I. Perla, *Intl. J. Non-Linear Mech.* **8**, pp. 253-259, 1973.

309-08437-810-00

WATER YIELD IMPROVEMENT FROM SUBALPINE FOREST AND RANGELANDS, FORT COLLINS, COLORADO

(*e*) See Water Resources Research Catalog.
(*f*) Discontinued.
(*h*) **The Relation of Snow Transparency to Density and Air Permeability in a Natural Snow Cover,** J. D. Bergen, *J. Geophys. Res.* **76**, pp. 7385-7388, 1971.
Snow Amount in Relation to Streamflow and Herbage Production in Western Colorado, E. C. Frank, *J. Range Manage.* **26**, pp. 32-34, 1973.
Rime Contributes to a Water Balance in High-Elevation Aspen Forests, H. L. Gary, *J. For.* **70**, pp. 93-97, 1972.
Areal Snow Cover and Disposition of Snowmelt Runoff in Central Colorado, C. F. Leaf, *USDA For. Serv. Res. Paper RM-66*, 19 pages, 1971.
Simulating Effects of Harvest Cutting on Snowmelt in Colorado Subalpine Forest, C. F. Leaf, G. E. Brink, in *Watersheds in Transition Symp.*, pp. 191-196, Fort Collins, Colo., June 1972.
Computer Simulation of Snowmelt Within a Colorado Subalpine Watershed, C. F. Leaf, G. E. Brink, *USDA For. Serv. Res. Paper RM-99*, 22 pages, 1973.
Hydrologic Simulation Model of Colorado Subalpine Forest, C. F. Leaf, G. E. Brink, *USDA For. Serv. Res. Paper RM-107*, 23 pages, 1973.
Sampling Requirements for Areal Water Equivalent Estimates in Forested Subalpine Watersheds, C. F. Leaf, J. L. Kovner, *Water Resour. Res.* **8**, pp. 713-716, 1972.

309-09338-810-00

MULTI-RESOURCE MANAGEMENT OF SUBALPINE CONIFEROUS FORESTS, FORT COLLINS, COLORADO

(*c*) Robert R. Alexander, Project Leader.
(*d*) Experimental, field investigations, basic and applied research.
(*e*) Develop systems for integrating information relating to land management practices and predicting effects of timber harvesting practices on yield and quality of water and other resources.

309-09339-810-00

WATERSHED REHABILITATION TO CONTROL EROSION AND SEDIMENTATION IN THE SOUTHWEST, ALBUQUERQUE, NEW MEXICO

(*c*) Earl F. Aldon, Project Leader.
(*d*) Experimental, field investigations, applied research.
(*e*) See Water Resources Research Catalog.
(*h*) **Influences of a Forest on the Hydraulic Geometry of Two Mountain Streams,** B. H. Heede, *Water Resour. Bull.* **8**, pp. 523-530, 1972.
Functional Relationships and a Computer Program for Structural Control, B. H. Heede, J. G. Mufich, *J. Environ. Manage.* **1**, pp. 321-344, 1973.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, SOUTHEASTERN FOREST EXPERIMENT STATION, P. O. Box 2570, Asheville, N. C. 28802. J. B. Hilmon, Director.

311-0247W-810-00

IMPROVEMENT OF QUANTITY, QUALITY AND TIMING OF WATER YIELDS IN THE SOUTHERN APPALACHIANS-PIEDMONT

For summary, see Water Resources Research Catalog **8**, 3.0364.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, SOUTHERN FOREST EXPERIMENT STATION, T-10210 Federal Building, 701 Loyola Avenue, New Orleans, La. 70113. John C. Barber, Director.

312-06973-810-00

MULTI-RESOURCE MANAGEMENT OF FORESTS IN THE OZARK-OUACHITA HIGHLANDS

(*b*) Cooperative with the University of Arkansas.
(*d*) Field investigations; applied research.
(*e*) To formulate forest management alternatives to enhance values of water, timber and related forest resources. Hydrologic research is aimed at determining the effects of various silvicultural measures on streamflow and water quality. Measurement of hydrologic responses from partial and complete vegetation removal on three small watersheds in the Ouachita Mountains is continuing. Soil water changes, nutrients and herbicide residues in surface runoff and growth responses of shortleaf pine are being measured. Calibration of five watersheds in the Springfield Plateau is nearly complete and treatments are planned for early 1975. Soil water content is being monitored on three of these watersheds and the Ouachita watersheds and on plots in the Springfield Plateau. Calibration is underway on four 20-acre watersheds in the Boston Mountains.
(*g*) Results have indicated significant increases in runoff following partial and complete vegetation removal from the Ouachita Watersheds. Sediment losses increased immediately after timber removal, but quickly returned to pretreatment levels. Herbicide residues in runoff were found to be minimal after spraying and were only detected for a short period. Diameter growth of three sizes of shortleaf pine has significantly increased as a result of understory removal and thinning the pine overstory. Soil water deficits were significantly different between forested and clearcut areas in the Springfield Plateau. Growing season deficits in forested areas were over four times those on cut areas, while spring deficits were very similar under both cover conditions.

312-06974-810-00

HYDROLOGIC EVALUATION OF FOREST MANAGEMENT ALTERNATIVES FOR THE SOUTHERN COASTAL PLAIN PINERY

(*c*) Stanley J. Ursic, Project Leader, U. S. Forest Service, Forest Hydrology Laboratory, P. O. Box 947, Oxford, Miss. 38655.
(*d*) Field investigation; applied research.
(*e*) To quantify hydrologic responses to soil and vegetative disturbances in management of southern pine forests and develop predictive capability. Initial priority is hydrologic response to clearcutting of pine on erodible soils because it is imminent and represents the greatest hazard among harvesting methods. Important for large areas are hydrologic responses to drastic soil disturbances related to conversion of hardwoods to pine and site preparation to establish subsequent pine crops. Storm runoff, sediment production, and other water quality parameters are measured on plots or small catchments following harvesting and site preparation disturbances and on similar undisturbed sites for comparison. Soil and forest floor are characterized physically and chemically to help explain and predict responses. Disturbed areas are planted or naturally reseeded and recovery trends of soil, forest floor, and hydrologic responses are defined and correlated. Practical alternatives will be defined and developed if present management practices prove hydrologically unacceptable.
(*g*) Twenty-five years after loblolly pines were planted, sediment yields from small catchments averaged 0.03 ton/acre, confirming loblolly pine's efficiency in reducing soil losses. Sediment yields and dissolved nutrient losses from these pine plantations were primarily a function of stormflow volumes. Nutrient concentrations did not differ with flow rates. Dissolved nutrient losses in runoff were less than input by precipitation. Stormflow was proportional to area of catchment having restricted internal drainage. Rainfall on comparable hardwood-covered catchments with a clay subsoil reached channels rapidly via surface flow. Heavy thinning of pine reduced annual litter accumulation but stands still provided enough to protect soil. Clearcutting caused rapid litter deterioration and soil movement in three years. Hence, cover must be renewed rapidly after harvesting. Fungi active in breaking down litter were identified. Three-length skidding increased soil bulk density beneath wheel ruts of rubber-tired skidders to densities that may cause mortality of planted pine. Data suggest a return to undisturbed soil densities in 12 years. Skidding increased stormflow and sediment yields within skid trails but herbaceous growth reduced sediment yields in a few months.
(*h*) **Changes in the Forest Floor Under Upland Oak Stands and Managed Loblolly Pine Plantations,** B. P. Dickerson, *J. For.* **70,** 9, pp. 560-562, 1972.
Containerized Loblolly Pines Promising for Erosion Control Planting, B. P. Dickerson, *USDA Forest Serv. Tree Plant. Notes 24*, 1, pp. 35-37, 1973.
Seedling Age Influences Survival of Containerized Loblolly Pines, B. P. Dickerson, *USDA Forest Serv. Res. Note SO-171*, 4 pages, 1974.
Planting Grass and Pine for Erosion Control, P. D. Duffy, *USDA Forest Serv. Tree Plant. Notes 25*, 1,pp. 10-13, 1974.
Difficult Eroded Planting Sites in North Mississippi Evaluated by Discriminant Analysis, P. D. Duffy, D. C. McClurkin, *Soil Sci. Soc. Am. Proc.* **38,** 4, pp. 676-678, 1974.
Hydrologic Performance of Eroded Lands Stabilized with Pine, S. J. Ursic, P. D. Duffy, *Proc. Miss. Water Resour. Conf. 1972*, pp. 203-216, 1972.
Fungal Succession on Loblolly Pine and Upland Hardwood Foliage and Litter in North Mississippi, E. S. Watson, D. C. McClurkin, M. B. Huneycutt, *Ecology* **55,** 5, pp. 1128-1134, 1974.

DEPARTMENT OF THE AIR FORCE, AEROSPACE RESEARCH LABORATORIES, APPLIED MATHEMATICS RESEARCH LABORATORY, Wright-Patterson Air Force Base, Ohio 45433. Dr. D. A. Lee, Director.

313-09340-020-00

STATISTICAL THEORY OF FLUID TURBULENCE

(*c*) Dr. Jon Lee, ARL(LB), Bldg. 250, W-P AFB, Ohio 45433.
(*d*) Basic research.
(*e*) Provide a unified statistical mechanical framework for the turbulence theories based on the distribution function. For fluid turbulence, it is possible to evolve the distribution function of fictitious eddy particles as in statistical mechanics. In the past decade, theories have been proposed to deduce the modal-energy evolution from the Liouville equation for the eddy motion. The purpose of this work is to show how the theories of Edwards (1964), Herring (1965-66), and Balescu and Senatorski (1970) are inter-related, and hence may all be derived from a general starting point.
(*g*) The modal-energy and averaged Green's equations are derived by developing perturbation about three different states; the laminar flow (Balescu-Senatorski), a turbulent flow (Herring), and the Gaussian random process (Edwards). They are, indeed, in parallel to the different direct-interaction-approximation procedures which also involve perturbation about the same three states; the laminar flow (Wyld), a turbulent flow (Kraichnan), and the Gaussian random process (Phythian). Herring's modal-energy equation represents the simultaneous-time limit of Kraichnan's covariance equation. We have revised the derivation of Balescu and Senatorski, and have pointed out the difficulty in Edwards' theory due to the one-time nature of the distribution function formalism.
(*h*) **Statistical Mechanical Approaches to Fluid Turbulence,** J. Lee, *J. Math. Phys.* **15,** pp. 1571-1586, 1974.

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DEPARTMENT OF THE AIR FORCE, AIR FORCE INSTITUTE OF TECHNOLOGY (AU), AEROSPACE DESIGN CENTER AFIT/END, Bldg. 640, Wright-Patterson Air Force Base, Ohio 45433. Harold C. Larsen, Director.

314-09353-040-00

AN EXPERIMENTAL INVESTIGATION OF OPEN CAVITY PRESSURE OSCILLATIONS

(*c*) Dr. M. E. Franke.
(*d*) Experimental; thesis.
(*f*) Completed.

314-09354-630-00

OPERATIONAL CONSIDERATIONS OF A LOW PRESSURE, SMALL AREA RATIO EJECTOR

(*c*) Dr. H. E. Wright.
(*d*) Thesis.
(*f*) Completed.

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DEPARTMENT OF THE ARMY, U. S. ARMY BALLISTIC RESEARCH LABORATORIES, Aberdeen Proving Ground, Md. 21005. Dr. Robert J. Eichelberger, Director.

315-09355-010-00

FLOW FIELD PERTURBATIONS CAUSED BY PROTUBERANCES IN BOUNDARY LAYERS

(*c*) Dr. Raymond Sedney, Exterior Ballistics Laboratory, R. H. Kent Bldg.
(*d*) Theoretical and experimental applied research.
(*e*) Experimental flow visualization methods are being developed and used to study the local changes to a smooth surface boundary layer caused by a three-dimensional protuberance. Physical models of the near flow field are constructed. The Navier-Stokes equations are solved numerically for a two-dimensional square protuberance in Couette flow.
(*f*) Completed.
(*g*) The optical-surface indicator technique, developed in this task, has been used to resolve the details of the multiple flow separations and reattachments which occur in the flow field near a protuberance immersed in a supersonic turbulent boundary layer. We find that the number and size of vortices formed in the separated flow region are very dependent on the Reynolds number. We have visualized the flow off the surface using a laser-illuminated vapor screen technique. Flow separation and reattachment near square two-dimensional protuberances have been studied numerically using the full Navier-Stokes equations.
(*h*) **The Marriage of Optical, Tracer and Surface Indicator Techniques in Flow Visualization,** R. Sedney, C. W. Kitchens, Jr., C. C. Bush, *IEEE Pub. 73 CHO 784-9AES*, pp. 155-171, Sept. 1973.
A Survey of the Effects of Small Protuberances on Boundary-Layer Flows, R. Sedney, *AIAA J.* **11**, 6, pp. 782-792, June 1973.
The Effects of Steady, Three-Dimensional Perturbations in Boundary Layers, R. Sedney, *BRL Rep. 1748*, Nov. 1974.
BRL Develops New Technique for Fluid Flow Visualization, R. Sedney, C. W. Kitchens, Jr., *Army R&D Newsmagazine* **15**, 3, p. 13, May-June 1974.
Surface Flow Patterns for Supersonic Flow Past Cylindrical Protuberances, C. W. Kitchens, Jr., R. Sedney, *Bull. Amer. Phys. Soc.* **18**, 11, p. 1740, Nov. 1973.
Vapor Screen Visualization of Supersonic Flow Past Cylindrical Protuberances, C. W. Kitchens, Jr., R. Sedney, *Bull. Amer. Phys. Soc.* **18**, 11, p. 1471, Nov. 1973.
Separation and Reattachment Near Square Protuberances in Low Reynolds Number Couette Flow, C. W. Kitchens, Jr., *BRL Rep. 1695*, Jan. 1974.
Calculation of Low Reynolds Number Flow Past a Square Protuberance, C. W. Kitchens, Jr., *AIAA J.* **12**, 7, pp. 1005-1007, July 1974.
The Structure of 3-D Separated Flows in Obstacle-Boundary Layer Interactions, R. Sedney, C. W. Kitchens, Jr., *AGARD-NATO Symp. Flow Separation*, G(ttingen, Federal Republic of Germany, May 1975 (to be published).

315-09356-010-00

THREE-DIMENSIONAL BOUNDARY LAYERS

(*c*) Dr. Clarence W. Kitchens, Jr., Exterior Ballistics Laboratory, R. H. Kent Bldg.
(*d*) Numerical and theoretical applied research.
(*e*) The role of the zone of dependence concept in three-dimensional boundary-layer calculations is investigated. This concept is especially important for calculating the boundary layer over a spinning body at incidence. A new exact solution which simulates the essential features of the complex flow over a spinning body is used as a test case to test four finite-difference schemes. The stability properties of the finite-difference equations are being studied.
(*g*) A new exact solution is developed and used as a test case. Two new finite-difference schemes for three-dimensional boundary layers are developed. Four finite-difference schemes are tested to determine the effect of violating the zone of dependence rule. We show that error growth results from violating this rule in numerical computations; however, the two new schemes are shown to be fairly insensitive to these violations. We show that stability restrictions and the zone of dependence rule are not the same.

315-09357-540-00

SPIN-UP IN A LIQUID-FILLED SHELL

(*c*) Dr. Raymond Sedney, Exterior Ballistics Laboratory, R. H. Kent Bldg.
(*d*) Theoretical investigation, applied research.
(*e*) Investigation of instabilities occurring early in the flight of liquid-filled shells gives rise to the task of determining the unsteady flow of the liquid in a shell impulsively spun up from rest. An approximate model (E. H. Wedemeyer) has led to a single partial differential equation for the flow in a completely-filled shell with a cylindrical cavity. Here an economical, efficient and accurate numerical technique has been developed and applied to this spin-up equation. The program is set up for three "Ekman suction compatibility" conditions: 1) linear, laminar; 2) linear, turbulent; 3) Rogers and Lance, laminar. The program also integrates the velocity profiles to provide the angular momentum history of the fluid.
(*g*) Numerical solutions have been obtained for wide ranges of the parameters of the problem (dimensions of the cavity, kinematic viscosity and spin rate), providing a complete picture of the effects of the parameters on the velocity profiles. Comparison with analytical approximations show the conditions under which the latter are valid.
(*h*) **Viscous Effects in the Wedemeyer Model of Spin-Up from Rest – Numerical Solutions,** R. Sedney, N. Gerber, *Bull. Amer. Phys. Soc.*, p. 1159, Nov. 1974.

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DEPARTMENT OF THE ARMY, COASTAL ENGINEERING RESEARCH CENTER, Kingman Building, Fort Belvoir, Va. 22060. James L. Trayers, Colonel, CE, Commander and Director.

316-02193-490-00

COASTAL CONSTRUCTION – DEVELOP FUNCTIONAL/STRUCTURAL DESIGN CRITERIA

(*c*) R. A. Jachowski, Chief, Design Branch, Engrg. Development Division.
(*d*) Applied research and engineering design development.
(*e*) Development of functional and structural design criteria is directed at summarizing for design application, informa-

tion obtained through research by the Corps and others, compiling and synthesizing it, and finally translating it into a form directly usable by coastal engineers, and in a sense, is the end product of all CERC's research.

(*h*) **The Shore Protection Manual,** published by GPO is a three volume manual containing eight chapters and four appendices (1160 pages) and replaces *CERC TR 4*, **Shore Protection Planning and Design.**

Coastal Engineering Manual, a Coastal Engineering Manual is to be prepared to eventually supersede the SPM. The purpose of this manual is to provide the practicing engineer with a comprehensive publication encompassing all facets of coastal engineering. The format of the manual will comprise six chapters which will summarize the information included in detail in 24 appendices.

316-02195-430-00

EVALUATION OF SHORE PROTECTION STRUCTURES

(*d*) Field investigation; applied research.

(*e*) Evaluation of Shore Protection Structures is directed at providing improved functional design criteria for coastal projects through analysis of the behavior of selected prototype structures which have been built. Current design practice relies on many empirical relationships and coefficients that are generally based on insufficient data. By evaluating structure performance, techniques which have been obtained through empirical or analytical efforts can be confirmed, and the accuracy of coefficients determined. Data are collected before, during and after construction of shore structures, including repetitive surveys, material sampling, littoral forces (to the extent possible), and the techniques and materials of construction. Analysis of these data is aided by the use of electronic data processing techniques.

(*g*) Data processing continued for the following locations: Hampton Beach, N. H. – beach fill and nourishment; Wallis Sands Beach, N. H. – beach fill and terminal groin; Suffolk County, L. I., N. Y. – groin system; Carolina Beach Inlet, N. C. – dredging of throat of unimproved inlet; Carolina Beach, N. C. – beach fill, dunes, and nourishment; Wrightsville Beach, N. C. – beach fill, dunes, and nourishment from littoral reservoir at experimental weir-type jetty; Hunting Island, S. C. – beach fill and nourishment.

316-06995-880-00

COASTAL ECOLOGICAL STUDIES

(*d*) Field investigations; applied research.

(*e*) Three ecological problem areas relating to coastal engineering activities are being investigated: effects of structures, effects of nourishment of eroded beaches and the use of vegetation for engineering purposes such as dune creation and stabilization, bank erosion control, and spoil stabilization by marsh plants. Two planning studies have been completed and the results published. Several field studies have been initiated and some completed.

(*g*) Approaches to the problem of the ecological effects of structures (breakwaters, artificial islands, etc.) are in the planning stage, however, several studies of the effects of beach nourishment especially with sand from offshore sources are underway or completed. A study of the effect of beach nourishment on finfishes at Lido Key (Florida Gulf Coast) was completed as was a study of the effects of beach nourishment and offshore sand sources at several beaches in Broward County (Florida Atlantic Coast) on benthos, coral and fishes.

A two-year study of physical and biological conditions of beaches in the vicinity of Treasure Island (Florida Gulf Coast) has recently been completed, and a similar study initiated in the Panama City (Florida Gulf Coast). Several studies on the uses of vegetation for engineering purposes have been completed or are underway. Studies of dune creation and stabilization by the use of vegetation have established standard operational procedures and the study areas at Padre Island, Texas, Outerbanks, N. C., and Cape Cod, Mass., are now being monitored to follow the fate of the dunes and the vegetation with time. Field tests of a beach grass, running panicum, for stabilizing dunes are continuing. Creation of marsh on dredged material is continuing as are studies of the uses of vegetation for low cost bank erosion control.

(*h*) **Ecological Monitoring of Beach Erosion Control Projects, Broward County, Florida, and Adjacent Areas,** R. W. Courtenay, Jr., D. J. Herrema, J. Thompson, W. P. Azzinaro, J. van Montfrans, *Tech. Memo. No. 41*, USA Coast. Engrg. Res. Center, Feb. 1974.

Effects of Dredging and Filling for Beach Erosion Control on Fishes in Vicinity of Lido Key, Florida, H. T. Holland, J. R. Chambers, R. R. Blackman, a Final Report.

A Glossary of Ecological Terms for Coastal Engineers, A. K. Hurme, *MP 2-74*, USA Coast. Engrg. Res. Center, Mar. 1974.

Effects of Engineering Activities on the Ecology of Pismo Clams, J. Nybakken, M. Stephenson, a Final Report. To be published about Nov. 1975 by USA Coast. Engrg. Res. Center as a Tech. Memorandum.

Effect of Disposal of Dredged Material on Benthic Macrofauna in Monterey Bay, J. S. Oliver, P. N. Slattery, a Final Report.

The Use of Grasses for Dune Stabilization Along the Gulf Coast with Initial Emphasis on the Texas Coast, L. C. Otteni, B. E. Dahl, R. L. Baker, A. Lohse, *Rept. No. 120-Final Report for 1971-1972*, 1972, Gulf Universities Research Consortium.

Ecological Effects of Offshore Construction, G. A. Rounsefell, *J. Marine Science* **2,** 1, pp. 1-89, Marine Science Institute Bayon LaBatre, Ala., plus Appendices which include 71 pages of annotated references, 1972.

Effects of Suspended and Deposited Sediments on Estuarine Organisms, J. A. Sherk, a Final Report, Natural Resource Inst., Univ. of Md., College Park, Md., Mar. 1974.

Ecological Effects of Offshore Dredging and Beach Nourishment: A Review, J. R. Thompson, *MP 1-73*, p. 39, USA Coast. Engrg. Res. Center, Jan. 1973.

The Use of Grasses for Dune Stabilization Along the Gulf Coast with Initial Emphasis on the Texas Coast, D. W. Woodard, B. E. Dahl, R. L. Baker, D. E. Feray, a Final Report for 1968-69, Gulf Univ. Res. Corp., 1969.

The Use of Grasses for Dune Stabilization Along the Gulf Coast with Initial Emphasis on the Texas Coast, D. W. Woodard, B. E. Dahl, R. L. Baker, D. E. Feray, a Final Report for 1969-70, Gulf Univ. Res. Corp., 1970.

Grasses for Construction and Maintenance of Primary Duneline on South Texas Barrier Islands, D. W. Woodard, B. E. Dahl, *Abstract Volume, 2nd Natl. Coastal and Shallow Water Res. Conf.*, p. 273, 1971.

The Use of Grasses for Dune Stabilization Along the Gulf Coast with Initial Emphasis on the Texas Coast, D. W. Woodard, L. C. Otteni, B. E. Dahl, R. L. Baker, T. W. Bilhorn, a Final Report for 1970-71, Gulf Univ. Res. Consortium, *Rept. No. 114*, 1971.

Marsh Building with Dredge Spoil in North Carolina, W. W. Woodhouse, Jr., E. D. Seneca, S. W. Broome, *N. C. Agric. Expmt. Sta. Bull. No. 445*, 1972; distributed as a USA Coast. Engrg. Res. Center reprint.

316-09733-410-00

BEACH PROFILE STUDIES

(*c*) Dr. Craig Everts, Oceanographer, Research Division.

(*d*) Field investigation; applied research.

(*e*) Develop criteria for the design of protective sand beaches, and a predictive model that will provide early warning of potentially dangerous beach depletion. The primary source of data is repetitive surveys of beach profile lines at selected coastal localities. This profile data is correlated with environmental factors such as wave, tide, storm and

sand conditions, to the extent that they are known, and with engineering works, such as beach fills and groins.

(*g*) Results to date include a report on the residence time and longshore travel of beach fill obtained from the data on Atlantic City and the use of this data in more specific problems at certain localities.

(*h*) **Beach Profile Changes on Western Long Island,** C. H. Everts, *Coastal Geomorpho. Symp.*, Sept. 1972.

Behavior of Beach Fill at Atlantic City, New Jersey, C. H. Everts, A. E. DeWall, M. T. Czerniak, *14th Coast. Engrg. Conf.*, June 1974.

Basic Research to Analyze Time Sequence Changes in Beach Configuration in Response to Wind and Wave Conditions in the Coastal Region Between Hollywood and Jupiter, Florida, J. J. Richter, Final Report, 15 Feb. 1971.

An Investigation of Beach Changes Between Hollywood and Jupiter, Florida, J. J. Richter, Final Report, July 1974.

Sand Level Changes on Torrey Pines Beach, California, C. E. Nordstrom, D. L. Inman, Final Report, Aug. 1974.

Geometry of Profiles Across Some Inner Continental Shelves of the United States, C. H. Everts, W. N. Seelig, AGU, Apr. 1973.

Magnitude of Changes on Three New Jersey Beaches, C. H. Everts, A. E. DeWall, M. T. Czerniak, AAPG/SEPM, Apr. 1974.

316-09734-700-00

DEVELOPMENT OF A RUNUP WAVE DIRECTION GAGE

(*c*) R. J. Hallermeier, Coastal Processes Branch, Research Division.

(*d*) Applied and developmental experimental and field research.

(*e*) To utilize the characteristics of the runup profile of a wave passing a vertical cylinder to produce a practical instrument for the measurement of wave direction. Experimental data already available will be used to evaluate the best design for a field direction gage. Sensors will be designed, built and tested with both small and large scale laboratory waves and, if appropriate, in the field. Testing will consist of small scale laboratory tests, large wave laboratory tests and field tests, depending on the results of laboratory tests. The following are major phases of the work: Design and construction of a laboratory-size sensor; testing of the laboratory size sensor, including evaluation of three data processing procedures; construction and laboratory testing of a field-size sensor; testing field-sized sensor with signal processing procedures; final report preparation.

(*g*) The four papers listed below present analyses of the most important data obtained in previous exploratory laboratory tests. They document the crest transformation effect to be utilized in the proposed wave direction gage, the way in which the gage will operate, and the planned development effort. Presently, designs are being prepared for the sensing pile, the data acquisition, and the experimental situation in upcoming laboratory testing in a three-dimensional wave basin.

(*h*) **Wave Runup on Vertical Cylinders,** C. J. Galvin, R. J. Hallermeier, *Proc. 13th Coastal Engrg. Conf.*, pp. 1955-1974, Vancouver, 1972.

Development of a Shallow-Water Wave Direction Gage, R. J. Hallermeier, W. R. James, *Proc. Intl. Symp. Ocean Wave Measurement and Analysis*, pp. 676-712, New Orleans, 1974.

Nonlinear Scattering of Wave Crests at Thin Piles, R. J. Hallermeier, to be submitted to ASCE for publication in J. Waterways, Harbors and Coastal Engrg. Division.

A Nearshore Wave Direction Gage with High Precision, W. R. James, R. J. Hallermeier, to be submitted to ASCE for publication in J. Waterways, Harbors and Coastal Engrg. Division.

316-09735-470-00

ALASKA HARBOR RESEARCH (SEDIMENTATION IN HIGH TIDE RANGE AREAS)

(*c*) Dr. Craig Everts, Oceanographer, Research Division.

(*d*) Field investigation; applied research.

(*e*) Prediction of shoaling rates for Alaskan harbors prior to their construction and the application of this knowledge to siting harbors in areas of least shoaling. Field data from Nushagak Bay and Knik Arm, Alaska, have been collected. Included are data on sediment concentration, sediment size distribution and density; water salinity and temperature; water current velocity, wave characteristics, ice, tidal elevations, estuary bathymetry, tidal flat topography, tidal flat sediment characteristics and time changes in tidal flat surface elevation. Shoaling rates have been measured in a sedimentation test facility and in a prototype Alaskan half-tide harbor. The resulting data will be analyzed and techniques to predict shoaling rates will be developed.

(*g*) Results to date include a better understanding of the factors contributing to shoaling in Alaskan Harbors.

(*h*) **Shoaling Rates and Related Data from Knik Arm Near Anchorage, Alaska,** C. H. Everts, H. Moore, to be published as a Coastal Engrg. Res. Center Tech. Memorandum.

Shoaling Rate Prediction in Half Tide Harbors, for *ASCE Specialty Conf. in Ocean Engrg.*, June 1975.

Tidal Flat Accretion in Alaska, H. Moore, C. H. Everts, *Trans. Amer. Geophys. Union* **54**, 4, 1973.

Sediment Discharge by Two Glacial Melt-Water Streams in Alaska, C. H. Everts, *Trans. Amer. Geophys. Union* **55**, 4, 1974.

316-09736-410-00

SEAWARD LIMIT OF EFFECTIVE SEDIMENT TRANSPORT

(*c*) R. J. Hallermeier, Coastal Processes Branch, Research Division.

(*d*) Experimental and theoretical basic research.

(*e*) To define, in operational terms, a zone seaward of which wave-induced sediment transport can be considered negligible for coastal engineering purposes. Laboratory investigations of wave-induced sediment transport will define the seaward limit of effective sediment transport by approaching this zone from the seaward and landward sides. Experiments in a prototype oscillating water tunnel at the National Bureau of Standards will be used to identify conditions of incipient sand motion and the establishment of ripple motion, presumed to identify the seaward edge of the zone. Suspended sediment measurements in CERC laboratory facilities will be used to establish the landward side of this zone as the point where sediment is no longer suspended in significant quantities over ripples. Appropriate laser, photo electric, and acoustic equipment will be developed or investigated as part of this work unit.

(*g*) A literature review is being conducted and a theoretical framework fabricated to permit detailed planning of a coherent series of laboratory experiments to accomplish the objective of this project. The tools to be used in this experimental program are being developed. Progress towards acquiring a suitable laser velocimeter system for use in wave and sand flows has been made, and a contract investigation of the performance of the sediment concentration instrument to be used has been completed. A wave tank, a three-dimensional wave basin, and a prototype scale, sinusoidal-flow water tunnel will be available for experiments.

The first series of water-tunnel experiments has documented the onshore sand transport caused by permeability flow through a horizontal, naturally-ripped, single-size-sand bed when the primary flow just begins to erode the bed.

(*h*) **Design Considerations for a 3-D Laser Doppler Velocimeter for Studying Gravity Waves in Shallow Water,** R. J. Hallermeier, *Appl. Optics* **12**, pp. 294-300, 1973.

Sediment Transport Due to Oscillatory Waves, T. C. MacDonald, *Hydraul. Engrg. Lab. Rept. HEL 2-39*, Univ. Calif., Berkeley, 98 pages, 1973.

Investigation of the Operating Characteristics of the Iowa Sediment Concentration Measuring System, F. A. Locher, J. R. Glover, T. Nakato, *Iowa Inst. Hydraul. Res. Rept. No. 170*, 100 pages, Univ. Iowa, Iowa City, Iowa, 1974.

An Effect of Permeability on Sand Transport by Waves, K. E. B. Lofquist, CERC Tech. Memo. No. 62, Dec. 1975.

316-09737-700-00

DESIGN, ASSEMBLY, AND TESTING OF NEW RAPID SEDIMENT ANALYZER/DATA ACQUISITION SYSTEM CONTROL OF SAMPLING, ANALYSIS, AND OUTPUT FROM NEW RAPID SEDIMENT ANALYZER

(*c*) C. W. Judge, Supervisory Geologist, Research Support Division.
(*d*) Research and development.
(*e*) Design and test an improved method for determining particle diameters in the sand size range (1 mm to 63 microns) based on fall time through a column of water. The new system will employ a 1.5 meter water column 15 cm in diameter and an accumulating pan suspended from a sensitive electrobalance. Mass and wall effects will be reduced by the larger tube and increased sensitivity, thus requiring the introduction of a smaller sample; in addition use of the suspended pan and electrobalance will permit variation of the fall length so that a good distribution can be obtained from coarse sediments and still avoid unreasonably long analysis time for fine sediments. Output from the rapid sediment analyzer will be provided to a Data Acquisition System for computation of size class distribution and statistical parameters.
(*g*) Preliminary concepts and testing were completed under contract with Northwestern University (R. Gibbs). An initial design for a new Rapid Sediment Analyzer at CERC has been completed and final design specifications are currently being prepared.

316-09738-410-00

NEARSHORE GEOMORPHOLOGY AND SEDIMENT KINETICS

(*c*) G. M. Watts, Chief, Engineering Development Division.
(*d*) Applied research.
(*e*) A program designed to measure currents and waves in coastal areas and relate the results to sediment transport, bedforms and the performance of engineering structures along coastlines. Field studies are conducted with a mobile amphibious unit. Both temporal and spatial variability of along-shore and onshore-offshore currents are tested and the results are evaluated in respect to wave conditions and properties of the bottom sediments.
(*f*) Suspended.
(*g*) Design of the mobile unit complete with sensors and an onshore data acquisition facility has been completed and tested under field conditions.
(*h*) **Instrument Array on a Mobile Platform for Measuring Longshore Currents,** P. G. Teleki, et al., *2nd Natl. Coastal and Shallow Water Conf.*, 1971.

316-09739-710-00

PHOTOGRAMMETRIC TECHNIQUES IN THE STUDY OF NEARSHORE PROCESSES

(*c*) G. M. Watts, Chief, Engineering Development Division.
(*d*) Applied research.
(*e*) A program designed to test photographic and photogrammetric techniques applied to water tracing dyes for charting circulation patterns and diffusion of coastal and estuarine water masses. Study includes the identification of water tracing substances, the testing of spectral properties and stability of selected dyes, evaluation of aerial platforms, film formats and film-filter combinations suitable for either salt – or fresh, clear or sediment laden waters and experiments designed to record surface currents and the dispersion characteristics of coastal and estuarine water masses. Results are compared to in-situ measurements of shallow water currents and calibrated by concentration measurements of the dyes.
(*f*) Suspended.
(*g*) Field experiments which have been conducted in both fresh and salt waters have yielded information of the most suitable dye-film-filter combinations. Separation of tracers as function of sediment content is yet to be accomplished. Additionally the data provided information on the shore-normal distribution of surface currents outside the zone of breaking waves.
(*h*) **A Study of Oceanic Mixing With Dyes and Multispectral Photogrammetry,** P. G. Teleki, et al., *Proc. ASP Symp. Remote Sensing in Oceanography*, pp. 772-787, 1973.
Photogrammetric Experiments on Nearshore Mixing and Diffusion, P. G. Teleki, D. A. Prins, *Proc. 2nd Intl. Conf. on Port Ocean Engrg. Under Arctic Condition*, 1974.

316-09740-420-00

MEASUREMENT OF OCEAN WAVES

(*c*) E. F. Thompson, Hydraulic Engineer, Research Division.
(*d*) Field investigation; applied research.
(*e*) In order to better define the characteristics of waves in the coastal zone, wave records are obtained from gages near the shores of the Great Lakes, the Atlantic Ocean, Gulf of Mexico and the Pacific Ocean. Recorded data are edited and spectra computed for the observations near 0100, 0700, 1300, 1900 EST each day. Monthly summaries of significant wave height and period are prepared. Spectra are plotted for cases of special interest. Aerial photographs of the coastal zone are inspected for information about wave characteristics.
(*g*) Aerial photographs indicate that the sea in the coastal zone is generally composed of from two to five distinct wave trains, each with well-defined wave length and direction. Long crested waves are common, but the interference patterns generated by the presence of two or more wave trains of similar height and period often appear confused when observed from a low elevation. In many computed spectra, most of the energy is confined to a narrow band, much more narrow than in most proposed theoretical spectra. In a few cases, the spectral density is nearly uniform for periods from three to fifteen seconds. In most spectra, however, two or more distinct peaks can be identified. It is presumed that these usually correspond to distinct wave trains as seen in the photographs.
(*h*) **Wave Estimates for Coastal Regions,** D. L. Harris, in *Shelf Sediment Transport*, edited by Swift, Duane and Pilkey, Dowdem, Hutchinson, & Ross, Inc., Stroudsburg, Pa., 1972.
Characteristics of Wave Records in the Coastal Zone, D. L. Harris, in *Waves on Beaches and Resulting Sediment Transport*, Academic Press, Inc., New York and London, 1972.
Finite Spectrum Analyses of Wave Records, D. L. Harris, *Proc. Intl. Symp. Ocean Wave Measurement and Analysis, ASCE*, New Orleans, La., Sept. 9-11, 1974.
CERC Field Wave Gaging Program, H. G. Peacock, *Proc. Intl. Symp. Ocean Wave Measurement and Analysis, ASCE*, New Orleans, La., Sept. 9-11, 1974.
Results from the CERC Wave Measurement Program, E. F. Thompson, *Proc. Intl. Symp. Ocean Wave Measurement and Analysis, ASCE*, New Orleans, La., Sept. 9-11, 1974.

316-09741-710-00

RADIOISOTOPIC SAND TRACER

(*c*) C. W. Judge, Supervisory Geologist, Research Support Division.
(*d*) Research and development.
(*e*) A second generation system has been designed and tested. Operation of the system provides a means of tracing the movement of radioactive tagged sand in-site over a wide area in the coastal zone and around engineering structures; all major zones of movement (beach, surf zone, and overshore) may be simultaneously surveyed. Basically the system consists of a ball-like device housing four scintillation detectors which is towed by electromechanical cable behind a LARC amphibious vehicle. On board the LARC, pulses from the scintillation detector are counted for two second intervals and the counts are then combined with range readings from the navigation system and with depth readings from the digital fathometer. This data is teleme-

tered to a shore-based mini-computer which analyzes the data and provides an areal plot of radiation intensities. Data is also stored on magnetic tape for further analysis at CERC. In addition to radiation tracer surveys, the system provides a convenient means of conducting automated bathymetric surveys. The system is now fully operational and is currently being utilized in support of littoral drift studies at Channel Islands Harbor.

(*f*) Completed.

(*g*) Development of an automated system for tracing littoral movement and obtaining bathymetric surveys.

(*h*) **Use of Radioisotopic Sand Tracer (RIST) System,** C. W. Judge, *Tech. Memo. No. 53*, USA Coastal Engrg. Res. Center, June 1975.

316-09742-440-00

EFFECTS OF LONG-TERM GREAT LAKES WATER LEVEL CHANGES

(*c*) Dr. C. J. Galvin, Chief, Coastal Processes Branch, Research Division.

(*d*) Field investigation; applied research.

(*e*) Evaluation of beach effects especially bluff recession resulting from the current high lake levels and the prediction of probable beach changes that will occur during future episodes of high lake level. Field surveys of 17 profile lines along the eastern coast of Lake Michigan have been made at four-week intervals for four years. These data will be correlated with environmental factors such as lake level, wave conditions and foreshore and backshore sand samples.

(*g*) Results to date include several reports that point out that bluff recession is highly variable along the shoreline and that storms during late fall seem to cause the largest changes in the shorelines.

(*h*) **Bluff Recession on East Coast of Lake Michigan,** P. C. Pritchett, *Abstract, 17th Conf. Great Lakes Res.*, Aug. 1974.

Beach Profile Changes, East Coast of Lake Michigan, 1970-1972, P. C. Pritchett, R. A. Davis, W. G. Fingleton, Coastal Engrg. Res. Center.

A Study of Shore Erosion at Seventeen Sites Along Eastern Lake Michigan, W. G. Fingleton, unpublished *M.S. Thesis*, Western Michigan Univ., June 1973.

Systematic Study of Coastal Changes, Eastern Lake Michigan – 1970-73, R. A. Davis, a draft Final Report, *DACW72-73-C-0003*, 1975.

316-09743-410-00

LITTORAL TRANSPORT TESTING PROCEDURES

(*c*) Charles B. Chesnutt, Hydraulic Engineer, Research Division.

(*d*) Experimental, basic research.

(*e*) Obtain predictions of time scale and geometric similarity for laboratory tests involving sediment motion (scale effects studies); and to understand the effect of water temperature, tank length, and wave reflection, refraction and diffraction in laboratory tests involving sediment motion (laboratory effects studies).

Tests, primarily in CERC wave tanks and basins will include: 1) Scale effects studies: Two-dimensional tests to empirically evaluate the performance of different sediments under a variety of wave conditions with a controlled water temperature. 2) Laboratory effects studies: Two-dimensional tests to empirically identify the magnitude of water temperature, tank length, and reflection effects by testing extreme conditions, and then, if important, by systematically testing intermediate conditions. 3) Scale and laboratory effects: Two-dimensional tests to check critical physical predictions based on predicted wave-induced bottom velocity and the known temperature dependence of viscosity. 4) Laboratory effects: Three-dimensional laboratory tests to evaluate effects of diffraction and refraction, and to evaluate results from items 1, 2, and 3.

(*g*) For constant incident wave conditions in four experiments with a movable sand bed, the reflection coefficient (K_r) varied from 0.05 to 0.30. This indicates a possible range of measured wave heights from 0.25 to 0.47 ft for the nominally constant 0.36 ft height used in these four experiments. Under the same wave conditions, K_r from a 1:10 concrete slab varied only from 0.03 to 0.07. The variation in K_r correlates well with profile changes. Because of the variable profile reflectivity, incident wave measurements to characterize a coastal engineering experiment should be based on calibration of the wave generator rather than spot wave measurements during the experiment.

(*h*) **Lab Profile and Reflection Changes for $H_o/L_o = 0.02$ Inch,** C. B. Chesnutt, C. J. Galvin, *Proc. 14th Intl. Conf. Coastal Engrg.*, 1974.

316-09744-410-00

CHECKLIST FOR LONGSHORE TRANSPORT PREDICTION

(*c*) Philip Vitale, Civil Engineer, Research Division.

(*d*) Experimental; development.

(*e*) Develop a checklist for computing longshore transport rates to be used by engineers in Corps Districts and Divisions. Laboratory, field and office procedures will be used to evaluate existing methods for the prediction of longshore transport rates. Laboratory and field procedures will be used to test critical questions and office studies will be used to document and evaluate methods. Particular items include documentation of the existing longshore energy flux method; laboratory tests to compare energy flux with longshore force as a predictor of transport rates; evaluation of the relative importance of suspended sediment in contributing to total longshore transport rate; preparation of a recommended check list for longshore transport rate prediction. Each of these four items would be accompanied by a report documenting the results obtained.

(*h*) **The Shore Protection Manual,** Chapter 4, pp. 4-88 to 4-111.

Longshore Sediment Transport Rates: A Compilation of Data, M. M. Das, *Coastal Engrg. Res. Center MP 1-71*, Sept. 1971.

Suspended Sediment and Longshore Sediment Transport Data Review, M. M. Das, *13th Intl. Conf. Coastal Engrg.*, Chap. 54, pp. 1027-1048, 1973.

Longshore Transport of Suspended Sediment, J. C. Fairchild, *13th Intl. Conf. Coastal Engrg.*, Chap. 56, pp. 1069-1088, 1973.

A Gross Longshore Transport Rate Formula, C. J. Galvin, *13th Intl. Conf. Coast. Engrg.*, Chap. 50, pp. 953-970, 1973.

Longshore Energy Flux, Longshore Force, and Longshore Sediment Transport, C. J. Galvin, *EOS, Trans. AGU* **54,** p. 334, Apr. 1973.

316-09745-430-00

PROTOTYPE EXPERIMENTAL GROIN

(*c*) D. W. Berg, Chief, Evaluation Branch, Engineering Development Division.

(*d*) Experimental field investigation; applied research.

(*e*) The prototype experimental groin study investigates various configurations. The objectives of the study are to determine the manner in which a groin functions to entrap sand; to determine the effect of groin dimensions and shape on the volume of entrapped sand; and, to determine the manner in which sand moves over, around, or through a groin. To accomplish the above objectives entails measurements of the littoral factors such as beach and nearshore underwater geometry, wave climatology, beach and nearshore underwater bottom sediment characteristics. The resulting relationships will be published and made available to interested organizations for use in the functional design of groins and groin systems.

(*g*) A pier was built at Pt. Mugu, California, in 1969 by the Coastal Engineering Research Center. Using the pier as a

work platform and supporting structure, two groins have been installed and tested. The first groin configuration was long, high and impermeable; the second was short, low and impermeable. Both of the groins influenced the shoreline and offshore depths for a distance, in the downcoast direction, equal to about three times the effective length of the groin and in the up coast direction for a distance equal to about five times the effective length of the groin.

During 1974, a third groin configuration was installed. This groin is low, short and permeable. The permeability was achieved by skipping every third piling in a sheet pile wall. As of January 1975, no visible effect on the shoreline in either direction can be observed.

316-09746-410-00

BEACH FILL SEDIMENT CRITERIA

(*c*) G. M. Watts, Chief, Engineering Development Division.
(*d*) Applied research involving theoretical and field investigations.
(*e*) Provide guidelines for District use in scheduling optimum available material for beach fills and determine amount of material required. To obtain and analyze field and model data in order to improve the characterization of littoral materials as guidance for specifying, in BEC studies those materials which will provide a more stable beach considering slope, wave, and current regime of a particular coastal sector. Information will be summarized in form of charts and tables suitable for engineers in planning, design, construction, and maintenance of beaches. To attain objectives, investigation includes collection of data related to temporal and spatial changes in beach and offshore profiles, as well as beach and offshore sediment characteristics; additionally, temporal modifications to the profile and sediment at beach nourishment/fill/bypass operations will be monitored. Data obtained will be analyzed and information incorporated into conceptual and mathematical models for interaction to subsequent field data collection programs. Field data from the Atlantic, Gulf, Pacific, and Great Lakes will be obtained. Because a large number of sediment samples will need to be analyzed investigation of temporal and spatial variability of sediment textural properties will be examined in order to assess sampling error, measurement error, information loss through data processing so as to improve the quality of sediment textural data collected by and stored at CERC and used as prime data base for this work unit.
(*g*) A mathematical model has been developed which relates beach recession rates to the grain size distribution of borrow material. Field studies are being designed to test this model.
(*h*) **Beach Fill Stability and Borrow Material Texture,** W. R. James, *14th Intl. Conf. Coast. Engrg.*

316-09747-710-00

COASTAL IMAGERY DATA BANK

(*c*) D. W. Berg, Chief, Evaluation Branch, Engrg. Development Division.
(*d*) Field investigation, operation and development.
(*e*) Proposed project is to index available controlled aerial photography of the coastal and estuarine areas of the United States.
(*g*) The indexing as described in (e) above is done on a U. S. Army Corps of Engineers District area basis. Indexing for the following Engineer Districts is complete: NAB, SAN, NPS, NPP, SPN, SAJ, NAO, SAW, NAP, NCB, NCE, NCC.

316-09748-700-00

AUTOMATIC PROFILE SOUNDING SYSTEM

(*c*) T. L. Miloser, Electronics Technician, Research Support Division.
(*d*) Experimental.
(*e*) Design of the Automatic Profile Sounding System (A.P.S.S.) is in progress. The A.P.S.S. will be used to measure the sand profile in the CERC Laboratory Shore Processes Test Basin. A single beam helium-neon laser and associated electronics is being used as the measuring instrument. The measurement will be accurate to 0.01 ft ± 0.002 ft. The laser will be mounted on a movable support carriage and will traverse in two straight axes 90° apart in the same horizontal plane above the shore processes test basin.

This laser system will enable sand profiles to be made with water remaining in the test basin and without disturbing the sand. Thus, sounding the basin after each wave generation period will measure the sand movement caused by the water waves.

The laser gage profile data will be connected directly to a computer type data acquistion system and will be stored on magnetic tape for analysis. A computer printout plot of the sand profile will also be available.

316-09749-700-00

QUEEB MULTIPLEXER SYSTEM

(*c*) E. A. Maiolatesi, Electronics Technician, Research Support Division.
(*d*) Development.
(*e*) A digital telemetry link was developed and successfully tested on ocean wave data originating in California and recorded on a computer in Virginia. The system receives its input from four analog sensors, digitizes the data four times per second, transmits it at a rate of 146 bits per second over a phone line, and outputs it to a computer or data logger and an electronic display.
(*f*) Completed.

316-09750-410-00

GREAT LAKES INLET STUDIES

(*c*) R. M. Sorensen, Chief, Special Projects Branch, Research Division.
(*d*) Field experiment; applied research.
(*e*) Data are being collected on short-term water level fluctuations and resulting inlet velocities, hydrographic changes, and wind and wave climate at selected inlets throughout the Great Lakes. This information is being used to test hydraulic theories and to develop predictive parameters and techniques which can be used to understand the interactions maintaining existing inlets and to design and predict future effects. Initial field investigations included a compilation and analysis of historical data, and a preliminary study of the hydraulics of inlets on Lake Michigan. Eight weeks of data were collected during the fall 1974 and are now being analyzed for Pentwater, Portage, Ludington, White Lake, Muskegon and Holland inlets on the east coast of Lake Michigan.
(*g*) Hydraulics of some inlets is controlled by coupling of the inlet/bay Helmholtz mode with high frequency modes of oscillation of the Great Lakes. This mode of oscillation causes periodic high velocities in the inlet for small water level changes. Other modes of oscillation cause much smaller inlet velocities.

316-09751-410-00

GENERAL INVESTIGATION OF TIDAL INLETS

(*c*) R. M. Sorensen, Chief, Special Projects Branch, Research Division.
(*d*) Experimental; theoretical, and field; applied research and development.
(*e*) Determine the effects of wave action, tidal flow, and related forces on inlet stability and on the hydraulic, geometric, and sedimentary characteristics of tidal inlets; to develop the knowledge necessary for design of effective navigation improvements and new inlets; to evaluate the water transfer and flushing capability of tidal inlets; and to define the processes controlling inlet stability.

(*g*) An office study is being conducted to classify inlets on the basis of their geometry, hydraulics, and stability. The hydraulic characteristics of a number of idealized inlet configurations are being defined through the use of a fixed bed model. An evaluation of physical and mathematical modeling capabilities for prediction of inlet hydraulics is being conducted, as well as an evaluation of the state-of-the-art of inlet movable bed modeling. Field data from a number of inlets are being collected and analyzed to define the significant processes controlling the dynamics and hydraulics of tidal inlets.
(*h*) Twenty reports on different aspects of this study have been completed through at least the first draft stage. Most will be published during 1975.

316-09752-410-00

CHANNEL ISLANDS LONGSHORE TRANSPORT STUDY

(*c*) D. W. Berg, Chief, Evaluation Branch, Engrg. Development Division.
(*d*) Field investigation, applied research.
(*e*) Data including repetitive surveys, sand samples and wave climatology are collected at the Channel Islands Sand Trap. The purpose is to determine an empirical relationship between longshore energy flux and longshore material transport.
(*g*) A preliminary analysis of the data collected indicates that although points (transport versus energy flux) plot above the existing relationship ("Shore Protection Manual") this relationship is a reasonable approximation to the actual relationship. A new survey technique is being tested at the study site. This is an integrated system for horizontal positioning of the survey vessel, depth sounding and transmitting data via radio to a shore based office. At the shore based office the incoming data is processed in real time by a mini-computer and stored on magnetic tape for processing immediately upon completion of the survey. This system allows the survey vessel to be guided along a preselected course by plotting the position of the vessel on a storage scope which is located in the shore based office.

316-09753-420-00

WAVE REFRACTION CALCULATIONS

(*c*) D. Lee Harris, Chief, Oceanography Branch, Research Division.
(*d*) Applied research involving both field investigations and theory.
(*e*) Evaluate algorithms for refraction calculations by comparing results of calculations with photographs or radar imagery of coastal zone waves. Develop improved algorithms as needed.

316-09754-430-00

FLOATING BREAKWATERS

(*c*) D. Lee Harris, Chief, Oceanography Branch, Research Division.
(*d*) Applied research involving both theory and field investigations.
(*e*) The floating breakwater at Friday Harbor, Washington, has been instrumented to measure the wave attenuation, breakwater motion and anchor chain stresses. A theoretical model for the breakwater performance is being developed. Actual performance and theoretical performance will be compared. Work is being performed by the University of Washington.

316-09755-420-00

WAVE PREDICTION MODELS

(*c*) D. Lee Harris, Chief, Oceanography Branch, Research Division.
(*d*) Applied, experimental.
(*e*) A modern algorithm for predicting wave spectra will be integrated for a set of idealized conditions to develop replacement for the nomograms in the CERC Shore Protection Manual.
(*f*) Potentially useful wave prediction models are being evaluated.

316-09756-420-00

STORM SURGE CALCULATIONS

(*c*) D. Lee Harris, Chief, Oceanography Branch, Research Division.
(*d*) Theoretical and experimental applied research.
(*e*) A two-dimensional numerical storm surge model, previously used for Galveston Bay, is being modified for use for the Charleston estuary and will later be generalized for use with any estuary. Wind fields are obtained from the National Weather Service. The model for Charleston will be used to estimate the maximum water levels in the estuary, associated with the water level having a return period of one hundred years on the open coast.

316-09757-420-00

WAVE RUNUP AND OVERTOPPING

(*c*) R. M. Sorensen, Chief, Special Projects Branch, Research Division.
(*d*) Experimental, applied research.
(*e*) Produce design curves relating the runup and overtopping of a spectrum of waves on a variety of structures to the basic characteristics of the structures and wave conditions. Testing will be conducted in wave tanks using both monochromatic and irregular waves. The testing will use structures having a variety of slopes, both plane and compound, and surface roughnesses. The runup of monochromatic and irregular waves will be related to make the large amount of existing runup data for monochromatic waves more useful for actual design conditions. The study will produce prediction methods for runup and overtopping that are based on observable or predictable characteristics of real waves.
(*g*) A preliminary study of runup of monochromatic and simple irregular waves (two and three monochromatic components mixed) on a 1:10 smooth slope has been conducted. For irregular waves, there were more incident wave crests than runup crests. As wave conditions increase in complexity the maximum runup divided by the r.m.s. incident wave water surface elevation increases. There is a good correlation between maximum runup and maximum wave crest amplitude. The ratio of maximum runup to maximum crest amplitude decreased as wave complexity increased.
(*h*) **Wave Runup on a 1 on 10 Slope,** J. P. Ahrens, *Tech. Memo.* (in publication), U. S. Army Coast. Engrg. Res. Center.

316-09758-420-00

WAVE REFLECTION FROM AND TRANSMISSION THROUGH POROUS STRUCTURES

(*c*) R. M. Sorensen, Chief, Special Projects Branch, Research Division.
(*d*) Experimental and theoretical; applied research.
(*e*) Developa direct analytical method for determining the wave reflection and transmission characteristics of trapezoidal, multilayered rubble mound structures. This is being accomplished through a two-year contract with MIT to develop the basic method supplemented by evaluation experiments at CERC with monochromatic and irregular waves.
(*g*) Formulas for the direct analytical determination of the wave reflection and transmission characteristics of a crib-style porous structure have been developed. Also, a combined theoretical-experimental determination of the energy dissipation characteristics of the rough plane seaward slope of a breakwater has been completed.
(*h*) **Wave Transmission Through Porous Structures,** O. S. Madsen, *J. Waterways Harbors and Coastal Engrg. Div., ASCE,* Aug. 1974.

316-09759-420-00

LABORATORY MODELING OF OCEAN WAVES

(*c*) D. Lee Harris, Chief, Oceanography Branch, Research Division.
(*d*) Theoretical and experimental; applied research.
(*e*) An algorithm modeled on that used for the analysis of tide records will be used to develop the response function for a programmable wave generator. This response function will be used to develop the input to a mini-computer which will control a hydraulic wave generator to produce desired wave spectra in laboratory.
(*f*) Software is partially developed. The laboratory facility needed for experimental work is not yet available.

316-09761-410-00

INNER CONTINENTAL SHELF SEDIMENT CHARACTERISTICS

(*c*) G. M. Watts, Chief, Engrg. Development Division.
(*d*) Applied research involving field investigations.
(*e*) To determine the characteristics and extent of materials combining the bottom and subbottom of the inner continental shelf in the zone shoreward of approximately the 120-foot (35 meter) depth contour for purposes of identifying those materials or deposits for beach fill or periodic nourishment, other needs, and relationships of sediment characteristics to regional geomorphology. To attain objectives, investigation includes collection of geophysical data (e.g. bottom and subbottom acoustical energy responses) and nominal 20-foot (6 meter) long cores of the subbottom material. These data are analyzed to determine sediment characteristics and areal extent of sand suitable for beach restoration or periodic nourishment purposes; collected data are also analyzed to better understand the sedimentation and regional geomorphology of the coastal segment under study. Because constraints for obtaining borrow material for beach fill purposes located inland or in backshore coastal zones are becoming more rigid, there is a need to perform the ICONS study along the entire Atlantic, Gulf, Pacific, and Great Lakes coast.
(*g*) Studies of the U. S. inner continental shelf, conducted to date along most of the Atlantic coast and along the coast of southern California, have delineated nearly ten billion cubic yards of sand suitable for beach restoration projects. Additional field programs are planned for Lake Michigan in 1975.
(*h*) **Geomorphology and Sediments of the Inner Continental Shelf, Cape Canaveral, Florida,** M. E. Field, D. B. Duane, *CERC TM 42*, 87 pages, 1974.
Geomorphology and Sediments of the Inner New York Bight Continental Shelf, S. J. Williams, D. B. Duane, *CERC TM 45*, 81 pages, 1974.
Buried Strandline Deposits on the Central Florida Inner Continental Shelf, M. E. Field, *Bull. Geolog. Soc. Amer.* **85**, pp. 57-60, 1974.

316-09762-410-00

DATA COLLECTION OF LITTORAL MATERIALS AND FORCES

(*c*) D. W. Berg, Chief, Evaluation Branch, Engrg. Development Division.
(*d*) Field investigation; applied research.
(*e*) Volunteer personnel use Littoral Environment Observation (LEO) techniques to measure basic forces and response elements in the nearshore beach zone. At each site daily observations are made of breaking wave height, period, and direction, type or character of breakers, longshore current velocity, wind speed and direction, foreshore slope, and rip current and cusp spacing. Monthly sand samples are analyzed to provide beach sediment characteristics. Dry beach profiles are made weekly. Where possible a multitude of sites are established in cooperative efforts (between State and local agencies and the local Corps of Engineers District Office), which continue daily data collection for several years. Data are machine processed, collated, and studied for long-term characteristics and trends. In addition to LEO other data collection efforts in Texas, Lake Michigan, northern and southern California, and Hawaii have been involved in procurance of profile data, sand samples, wave data, and aerial photography. Data are collected by concerned Corps of Engineers District methods. Objective is to procure and develop data that will be of use in planning and designing coastal projects.
(*g*) Cooperative LEO data collection efforts have been or are continued in the following coastal regions: southern California (15 sites, inactive), northern California (25 sites, inactive), Florida (6 sites, inactive), Michigan (25 sites, active), Wisconsin, Indiana, Illinois (15 sites, active), Texas (5 sites, active pilot program). Individual research efforts are not discouraged and volunteer efforts have been or are continued in Massachusetts, Virginia, North Carolina, Florida, Texas, Southern California, Pennsylvania, and Hawaii. Other data collection in Texas, Lake Michigan, northern and southern California, and Hawaii has been terminated and final reports are in preparation by Corps District Offices following completion of data analysis.
(*h*) **Analysis and Interpretation of Littoral Environment Observation (LEO) and Profile Data Along the Western Panhandle Coast of Florida,** J. H. Balsillie, *Tech. Memo. 49*, U. S. Army Corps of Engineers, Coast. Engrg. Res. Ctr., Ft. Belvoir, Va. 22060, Mar. 1975.
Surf Observations and Longshore Current Prediction, J. H. Balsillie, (in preparation), U. S. Army Corps of Engineers, Coast. Engrg. Res. Ctr., Ft. Belvoir, Va. 22060, 1974.
Systematic Collection of Beach Data, D. W. Berg, *Proc. 11th Conf. Coast. Engrg., ASCE*, Chap. 17, pp. 273-297, 1969.
Littoral Environmental Observation Program in the State of Michigan, R. O. Bruno, L. W. Hiipakka, *Proc. 16th Conf. Great Lakes Research*, Intl. Assoc. Great Lakes Res., pp. 492-507, 1973.
Characteristics of Lake Michigan Bottom Profiles and Sediments from Lakeside, Michigan to Gary, Indiana, E. F. Hawley, C. W. Judge, *Proc. 12th Conf. Great Lakes Res.*, Intl. Assoc. Great Lakes Res., pp. 198-209, 1969.
Littoral Environment Observation Program in California, A. Z. Szuwalski, preliminary report, Feb.-Dec., 1968, *Coast. Engrg. Res. Ctr. Misc. Paper 2-70*, p. 242, 1970.
San Francisco District, Corps of Engineers, San Francisco, California, U. S. Army, *Technical Report on Cooperative Beach Erosion Study of Coast of Northern California, Point Delgada to Point Ano Nuevo*, 1965.
Los Angeles District, Corps of Engineers, Los Angeles, California, U. S. Army, *Beach Erosion Control Report, Cooperative Research and Data Collection Program of Coast of Southern California, Cape San Martin to Mexican Boundary*, 1969.
Los Angeles District, Corps of Engineers, Los Angeles, California, U. S. Army Cooperative Research and Data Collection Program, Coast of Southern California, three year report, 1967-1979, 1970.

316-09763-410-00

LONG-TERM SHORELINE CHANGES

(*c*) G. M. Watts, Chief, Engrg. Development Division.
(*d*) Applied research involving field investigations.
(*e*) The objectives are to study, over the long-term ($\geq$ 3 yr), geologic processes affecting the development and migration of barrier islands, barrier beaches, and offshore bars especially the geometric as well as spatial and textural changes of these features through time, particularly in response to changes in sea level – or in the case of the Great Lakes, changes in lake level. Knowledge gained will provide engineers and scientists information to utilize in planning coastal engineering works and predicting effects of long-term lake level cycles, sea level changes, and natural barrier island-beach mobility on navigation protection

structures, shore protection structures, and planning for long-term use of coastal segments. Information will also aid in understanding regional continental shelf sedimentation processes and interrelationships between coastal and shelf geology. To attain objectives research involves interaction of and feedback between conceptual modeling, numerical modeling and field data collection and analysis. Conceptual modeling requires knowledge of geologic history and processes of coastal regions and continental shelf as a basis for design of field data collection programs and a framework within which to interpret and assess the collected information. Knowledge thus gained may be input to mathematical models attempting to numerically simulate motion of sediment caused by analysis of geophysical data (refraction, reflection, seismic techniques, bathymetric profiling, radioactive age dating) sediment cores and deep borings on land and nearshore, aerial photography and other remote sensing techniques.

(*g*) Existing concepts on origin and modification of barrier islands have been reviewed and synthesized; field data collected in 1974 is being evaluated. A tentative model has been developed for predicting qualitatively the response of sandy shores to long-term increases in water level. This model is based on a four-year record of profile development in the vicinity of a harbor on the Great Lakes. Fieldwork is being planned that will test the applicability of the invisioned model by reprofiling stations established in 1969 along a 55 kilometer reach of variable shore types on Lake Michigan. The resulting data will also serve as a base for monitoring profile adjustment to the anticipated decline in lake levels.

(*h*) **Post-Pleistocene Events on the Inner Continental Shelf and the Origin of Barrier Islands,** M. E. Field, D. B. Duane, *Bull. Geolog. Soc. Amer.*, in press.

Nature and Genesis of Some Storm Washover Deposits, R. K. Schwartz, *CERC Tech. Memo.*, in press.

Barred Coastal Profiles Under the Influence of Rising Water Levels, Observations Over a Four-Year Period, Eastern Lake Michigan, E. B. Hands, *CERC Tech. Memo.*, in press.

DEPARTMENT OF THE ARMY, DIVISION HYDRAULIC LABORATORY, NORTH PACIFIC DIVISION, CORPS OF ENGINEERS, Bonneville, Oreg. 97008. Peter N. Smith, Director.

317-00405-350-13

GENERAL MODEL STUDY OF ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) Ice Harbor Dam is located on the Snake River 9.7 miles upstream from the junction of the Snake and Columbia Rivers. Principal features include a powerhouse for six 90,000-kW generating units (initial installation is three units), a concrete gravity spillway with ten 50-foot wide bays, a navigation lock with net clear dimensions of 86 by 675 ft and a maximum single lift of 103 ft, and facilities for passing fish upstream over the dam. The purpose of the general model study was to determine flow conditions before, during, and after construction of the project. A 1:100-scale, fixed-bed model reproduced pertinent structures and 2.7 miles of Snake River channel adjacent to the dam.

(*f*) Completed.

(*h*) **Ice Harbor Dam, Snake River, Washington,** L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 22-1*, Nov. 1973.

317-00407-330-13

MODEL STUDY OF NAVIGATION LOCK FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 317-00405 for description of project. The hydraulic system for filling the lock chamber consists of wall intake manifolds, a longitudinal culvert in each sidewall, 12- by 14-foot, reverse-mounted tainter culvert valves, and wall discharge manifolds leading to five bottom laterals. Twelve ports, six on each side, discharge from each bottom lateral; ports in adjacent laterals are offset for clearance of opposing jets. The total area of ports is 1.2 times culvert area at the valves. In emptying, flow enters the lateral ports and passes through 12- by 14-foot culverts which bend 90 degrees just upstream from the vertical-lift downstream lock gate. Flow is released from a river outlet located 450 ft downstream from the stilling basin. The purposes of the model study were to check the original design and to develop improvements if necessary. A section of culvert adjacent to and including a single bottom lateral was reproduced in a 1:16-scale model. Principal features of the lock approaches, lock chamber, and hydraulic systems were reproduced in a 1:25-scale model.

(*f*) Completed.

(*h*) **Filling and Emptying System, Ice Harbor Lock, Snake River, Washington,** L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 32-1*, May 1973.

317-02662-350-13

GENERAL MODEL STUDY OF JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) John Day Dam is located on the Columbia River, 25 miles upstream from The Dalles, Oregon. The reservoir formed by the 5900-foot long dam provides 76 miles of slack water for navigation upstream to McNary Dam and 500,000 acre-feet of flood storage. The spillway, designed for a flow of 2,250,000 cfs, consists of twenty 50-foot wide bays separated by 12-foot wide piers. The crest gates (tainter), each 50 feet wide by 58.5 feet high, are operated by individual electric hoists. Sixteen 135,000 kW Kaplan turbines are to be installed initially in the powerhouse; ultimate installation 20 units with total capacity of 2,700,000 kW. The 86- by 675-foot navigation lock has a maximum single lift of 113 feet. Fish facilities include a powerhouse collection system, auxiliary water supply systems, and a 24-foot wide fish ladder with main sections sloped 1 on 10 on each side of the river. The purposes of the model study were to provide information concerning diversion methods, conditions for navigation and fish passage, water-surface elevations, and flow patterns for each phase of construction. A 1:80-scale model reproduced 2.9 miles of Columbia River channel and pertinent overbank topography adjacent to the dam.

(*f*) Completed.

(*h*) **John Day Dam, Columbia River, Oregon and Washington,** R. L. Johnson, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 90-1*, June 1972.

317-02666-850-13

MODEL STUDY FOR FISH LADDERS FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 317-00405 for description of project. The facilities for fish include a powerhouse collection system and a fish ladder with auxiliary water supply system on both sides of the river. The main portion of the north fish ladder is 16 feet wide and has a floor slope of 1 on 10. The 24-foot wide south fish ladder slopes 1 on 16.

(*f*) Completed.

(*h*) **Fish Ladders for Ice Harbor Dam, Snake River, Washington,** L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 92-1*, June 1974.

317-03577-350-13

GENERAL MODEL STUDY OF LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.
(*e*) Lower Monumental Dam is located at Snake River mile 41.6, about 32 miles upstream from Ice Harbor Dam. Principal features include a powerhouse for six generating units (ultimate installation), a navigation lock with net clear dimensions of 86 by 675 feet and a maximum single lift of 103 feet, an 8-bay gravity spillway, and a 16-foot wide fish ladder on each side of the river. The purpose of the model study was to investigate flow conditions that might occur during and after construction of the project. A 1:100-scale model reproduced approximately 2.4 miles of Snake River bed and overbank topography at the dam site.
(*f*) Completed.
(*h*) **Lower Monumental Dam, Snake River, Washington,** A. J. Chanda, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 102-1*, May 1974.

317-04504-350-13

GENERAL MODEL STUDY OF LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Little Goose Dam, at Snake River mile 70.3, is the third in a series of multiple-purpose dams being constructed above the mouth of Snake River for power, navigation, and other uses. Salient features include an 8-bay spillway, a navigation lock 86 feet wide by 675 feet long (maximum lift 101 feet), a powerhouse for six units (initial installation three 135,000-kW generators), and a 20-foot wide fish ladder on the south shore. A model study was necessary to determine minimum excavation requirements, to verify structure locations, and to check the overall effects of these structures on navigation, power generation, and fish passage. A general model, constructed to a linear scale ratio of 1:100, reproduced the river channel and pertinent overbank areas for 1.35 miles upstream and 1.90 miles downstream from the project axis.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

317-04505-850-13

MODEL STUDY OF FISHWAY DIFFUSERS FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) An existing 1:8-scale fishway diffuser model was revised so that two diffusion chambers were supplied by a single riser from the conduit. Included in the model were diffusers 3 and 4 and the common distribution well, the supply conduit, and a portion of the 16-foot wide south shore fish ladder that carried all flow which passed through the diffusion chambers. In the original design, a 7-inch wide control orifice was located 3.5 feet above the diffuser well floor, and 1.5 foot high ports admitted flow into the respective diffusion chambers. The information desired from this model includes: the orifice size required to provide 48 cfs through each diffuser with a head of 2 feet (supply conduit grade line minus tail-water elevation), a submergence of 4 feet (supply conduit grade line minus elevation of downstream weir adjacent to diffuser 3), and a conduit flow of 500 cfs; a family of rating curves for heads of from 0.5 feet to 6.0 feet and various submergences; and the effect on diffuser discharge of varying the conduit flow from about 50 cfs (only one diffuser) to 750 cfs while a constant head is maintained on the test diffuser.
(*f*) Completed.
(*h*) **Fish Ladders for Lower Monumental Dam, Snake River, Washington,** L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 109-1*, Dec. 1973.

317-05068-350-13

MODEL STUDY OF SPILLWAY FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-04504 for description of project. A 3-bay section of the 8-bay spillway and stilling basin was reproduced in a 1:42.45-scale model. The purposes of the tests were to check performance of the original spillway and to develop revisions that would improve performance or reduce construction and maintenance costs.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

317-05069-350-13

MODEL STUDY OF NAVIGATION LOCK FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-04504 for description of project. The intake manifolds, longitudinal culverts (both in right wall), lock chamber, split lateral filling and emptying system, outlet culverts, and portions of the approach and outlet areas were reproduced in a 1:25-scale model. An alternative method for distributing flow to the lateral culverts from a central junction chamber was studied in an auxiliary 1:25-scale model of the lock chamber. The purposes of the studies were to check the suitability of the original design and to develop improvements if necessary.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

317-05070-350-13

MODEL STUDY OF SPILLWAY FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Dworshak Dam, on the North Fork of Clearwater River will furnish 400,000 kW of power from three units (initial installation) and, ultimately, 1,060,000 kW from six units. The spillway consists of two 50-foot wide bays, with crest at elevation 1545, a chute, and a 114-foot wide, 271-foot long stilling basin at elevation 931. Three 9- by 12.5-foot regulating outlets, upstream from the tainter valves, and 11 by 17 feet downstream from valves, discharge on the spillway chute. Total capacity of the spillway and regulating outlets is 221,000 cfs at pool elevation 1604.9. Approximately 1.6 miles of river channel and pertinent overbank topography were reproduced in a 1:50-scale model to study the cofferdam and diversion tunnel. A section of forebay, the spillway, regulating outlets, stilling basin, powerhouse, tailrace, and exit channel were reproduced to determine hydraulic characteristics of these elements.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

317-05071-350-13

GENERAL MODEL STUDY OF LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Lower Granite Dam, at Snake River mile 107.5, is 37.2 miles upstream from Little Goose Dam. The 8-bay spillway, with 50- by 60.5-foot control gates (tainter) and the 498-foot wide, 167-foot long nonbaffled stilling basin are designed for a maximum discharge of 850,000 cfs. The 6-unit powerhouse will have a capacity of 810,000 kW; initial installation 405,000 kW from three units. The 86- by 675-foot navigation lock will have a maximum single lift of 105 feet. Fish facilities include a powerhouse collection system, three pumps for additional attraction flow (2550 cfs) and one 20-foot wide fish ladder with floor slope of 1 on 10. A 1:100-scale general model reproduced the riverbed and pertinent overbank topography between Snake River miles 106.1 and 108.9 and successive phases of construction. Construction stages, powerhouse tailrace limits and depths, navigation lock approaches, flow conditions affecting fish passage, and project operations were to be studied in the model.

(*g*) The first-step cofferdam and diversion channel were satisfactory after the channel entrance was modified and rock groins to aid fish migrations were added. Embankment and excavation limits for construction phases were determined. The effects of several stages of erosion downstream from the original stilling basin were investigated, and an improved basin design was developed with estimated maximum erosion in the tailrace. Satisfactory energy dissipation was obtained with the stilling basin raised 4 ft and a 9-ft end sill (originally 11 ft high). An undesirable eddy existed between the north fishway entrance and the navigation lock wall. Several combinations of walls, fills, and training wall extensions were tried in efforts to develop satisfactory conditions at the north fishway entrance. Development of modifications to reduce nitrogen supersaturation caused by spillway discharges was begun. Preliminary results indicate that 12.5-ft wide horizontal deflectors on the spillway ogee will produce stable "skimming flow" in the stilling basin for river flows up to the 10-year flood, and required energy dissipation will occur at high flows; see also 317-07120.

317-05315-350-00

MODEL STUDY OF REGULATING OUTLETS FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-05070 for description of project. The three regulating outlets, with intakes at elevation 1350, will operate under heads of from 95 feet at minimum pool elevation 1445 to 254.9 feet at maximum pool elevation 1604.9. Total outlet capacity will be 40,000 cfs at pool elevation 1604.9. Pressures, flow conditions, and discharge relationships were observed in a 1:25-scale sectional model that reproduced a portion of the forebay, the right conduit, and a section of the spillway chute. The purpose of the study was to check the adequacy of the original design and to develop revisions if necessary.
(*f*) Tests completed; final report in preparation.
(*g*) Four designs for a bellmouthed intake were studied. See 1970 issue for details.

317-05316-850-13

MODEL STUDY OF FISH LADDER FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-04504 for description of project. A 1:10-scale model was used for tests of a 20-foot wide fish ladder with floor slope of 1 on 10.
(*f*) Tests completed; final report in preparation.
(*g*) Velocities, flow patterns, and discharge relationships were determined in typical pools, flow-control section, and slot-type counting station.

317-05317-330-13

MODEL STUDY OF COLUMBIA RIVER, OAK POINT TO VANCOUVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The project will increase the navigation channel width from 500 feet to 600 feet and the depth from 35 to 40 feet between Columbia River miles 52 to 109 and from the mouth of Willamette River to Portland, Oregon. Project depths and widths will be maintained by a system of pile dikes and by dredging. Five separate movable-bed models with 1:300 horizontal and 1:100 vertical scales will be required to cover improvements in the Columbia River. The models will be used initially to check plans for constructing and maintaining the 40-foot channel. Later the models will be used to check operation and maintenance activities and new construction. The first two models include river miles 53 to 65 and 64 to 78, respectively. Work on the remaining three models has not begun.
(*f*) Scheduled tests of river miles 53 to 78 completed; final report in preparation.
(*g*) Shoaling indexes, based on results with an uncontrolled 40-foot deep navigation channel, were determined for each improvement plan tested in the models. Satisfactory plans are being developed for all problem reaches covered by both models. Alternative proposals, which would be more acceptable to local interests in the Longview-Rainier area (mile 66), were tested and the benefits of these plans were determined.

317-05318-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNITS FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-02662 for description of project. Proposed changes in the skeletonized powerhouse units called for placement of as much concrete in the powerhouse draft tubes as diversion requirements would allow. The proposed skeleton bay differed from the original contract plan and from that at the Dalles Dam, the only unit that had been model tested. The changes, which were necessary to meet an accelerated construction schedule, might have affected designs for powerhouses at Lower Monumental and Little Goose Projects. A typical skeletonized unit of the type to be used for diversion was reproduced to a scale of 1:25 in a flume with glass sides that allowed observation of flow within the test unit.
(*f*) Completed.
(*h*) **John Day Dam, Columbia River, Oregon and Washington,** R. L. Johnson, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 90-1*, June 1972.

317-07107-350-13

MODEL STUDY OF SECOND POWERHOUSE FOR BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The existing project includes an 18-bay spillway with vertical gates lifted by 350-ton gantry cranes, a powerhouse with total rated capacity of 518,000 kW from 10 main units and one station service unit, a navigation lock with net clear dimensions of 76 by 500 feet, and fish facilities on each side of the river. Head on the project varies between 30 and 70 feet. From four to ten additional units are proposed to utilize increased storage and peaking operations at upriver projects. A 1:100-scale fixed-bed model reproduces the existing structures, riverbed, and pertinent overbank topography between river miles 142.2 and 146.8. A remote controlled towboat and tow are used to evaluate the effect of additional power units on navigation. The purpose of the study is to confirm the site chosen for the second powerhouse and to study flow conditions affecting fish passage, navigation, and head on the project.
(*g*) Three structures and excavation plans were investigated. Tests of the recommended plan (with present lock and provision for a future lock on the Oregon shore and an eight-unit powerhouse on the Washington shore) were continued. Tests indicated that 12-ft-long horizontal deflectors at elev. 14 between piers on the spillway ogee will produce stable "skimming flow" in the stilling basin for normal tailwater levels with the present 10-unit powerhouse and spillway flows between 1,000 and 16,000 cfs per bay. This should reduce levels of dissolved nitrogen downstream from the spillway. Spillway operating schedules were developed to provide good conditions for upstream passage of fish. This information was used in 1974 to evaluate the effects on fish passage of prototype deflectors in bays 13, 14, and 15 of the 18-bay spillway; see also 317-07108.

317-07108-350-13

MODEL STUDY OF SPILLWAY GATE MODIFICATION FOR BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 317-07107 for description of project. Additional pondage at Bonneville Dam will be required to accomodate water released by future increased power peaking of upstream dams. All spillway gates will be made 60 ft high (some are 50 ft high) to provide the necessary pondage, and 10 of the gates will have individual hoists to allow remote control. The present gates cannot be operated under certain conditions because of vibration and a tendency to bounce. Remote control of spillway gates requires no known restrictions on spillway operation. A 1:25-scale model included one spillway bay, two half piers, one spillway gate, and a 60-ft wide section of stilling basin and adjacent approaches. The gate was free to move vertically in the gate slots. The study was extended to include the hydraulic characteristics of deflectors between the piers on the spillway ogee. These devices may reduce nitrogen supersaturation by causing air entrained by small to moderate spillway discharges to remain near the water surface. Purposes of the studies are to check performance of existing gate bottoms and proposed deflectors and to develop improved designs if required.
(*f*) Tests completed; final report in preparation.
(*g*) The original gate bottom and six alternative shapes were investigated. Flow control shifted rapidly between the bottom seal and upstream face of the existing gate. The shifting control and resulting changing forces on the gate bottom made the gate vibrate vertically in the gate slots. Alternative gate shapes had varied vertical distances between the bottom of the upper face and the horizontal seal. A distance of 2.61 ft between the bottom seal and the bottom of the upstream skin plate was recommended. With this design, vertical vibrations of the prototype gate will be negligible. Continuous horizontal deflectors 6-, 10-, 12-, and 15-feet wide were investigated. The selected 12-foot width was tested at elevations 12, 14, and 17. With the deflector at elevation 14, flow conditions in the stilling basin and pressures on the deflector were satisfactory for normal tailwater elevations and spillway flows to 10,000 cfs per bay.

317-07109-350-13

MODEL STUDY OF INCREASED POOL ELEVATIONS AT SPILLWAY OF CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) The existing project, located 51 miles below Grand Coulee Dam and 545 miles from the mouth of Columbia River, includes an excavated channel leading to an intake for 27 penstocks, a 20-unit powerhouse (initial installation 16 Francis turbines), and a spillway with nineteen 40-ft-wide bays surmounted by 9-ft-wide piers and 56.2-ft-high tainter gates. The spillway ogee was designed for a head of 41.6 ft on the crest, or 75 percent of the computed maximum total head of 55.4 ft at the project design flow of 1,250,000 cfs. Construction of a third powerhouse at Grand Coulee Dam will require additional storage and power units at Chief Joseph to use the increased flow. Present plans include raising the Chief Joseph pool from existing elevations 946 to maximum elevations 970, or up to 1.7 times the design head. Preliminary data on surge characteristics at the spillway were obtained in an existing spillway model that contained a standard high dam crest and piers with elliptical noses. The most suitable modifications (13-foot thick piers, 36-foot wide bays, gate radius 55 feet, gate trunnions at elevation 920 and 61.83 feet from existing crest axis) were studied in a 1:43.35-scale model. Water-surface elevations at the outlet of a 4-foot diameter relief tunnel in the right training wall were determined for uniform and varied operations of spillway gates during spillway flows of 50,000 to 550,000 cfs (powerhouse discharge 250,000 cfs).
(*f*) Tests completed; final report in preparation.
(*g*) The tests indicated that the original crest and stilling basin would be satisfactory. Surging of flow on higher, narrower spillway gates was severe at large partial gate openings. This unstable periodic surge resulted from the combined effects of structural geometry, large heads, and gate openings required to release desired flows. Surging in the narrow bays was reduced from a maximum of 10.8 feet (pool elevation 961.2 and gates open 35 feet) to 2.8 feet by suppressors that extended 4 feet from the side of each pier above the maximum nappe at free flow. Closing the right spillway gate allowed the relief tunnel to drain until the river discharge exceeded 800,000 cfs. A vertical deflector projecting 2 feet from the training wall just upstream from the relief tunnel outlet would reduce water levels in the tunnel and allow uniform spillway operation for most discharges.

317-07110-350-13

MODEL STUDY OF CONDUIT ENTRANCES FOR DWORSHAK DAM, IDAHO, AND LIBBY DAM, MONTANA

(*b*) U. S. Army Engr. Dist., Walla Walla and Seattle.
(*d*) Experimental; for design.
(*e*) Normal reservoir outflows at Dworshak and Libby Dams will discharge on the respective spillway chutes through conduits that operate under heads up to 250 feet on the regulating valves (tainter). Although conduit dimensions upstream from the valves differ (9 by 12.5 feet at Dworshak and 10 by 17 feet at Libby), the same type of bellmouthed intake will be used at both dams. The tentatively adopted "no-skew" intakes that were developed during the Dworshak conduit model study extended upstream beyond the face of the dam. This would have complicated design and use of unwatering bulkheads. A regulating conduit with streamlined entrance and a portion of forebay were reproduced in a 1:20-scale model for measurements of discharges, pressures, and other data. The purpose of the study was to develop revisions that could be used at Dworshak, Libby, or other projects.
(*f*) Tests completed; final report in preparation.
(*g*) Three designs for short, skewed, bellmouthed entrances for the Dworshak and Libby conduits were tested. Satisfactory plans for both entrances were developed.
(*h*) **Skewed Entrance for High-Head Conduits,** *Engineer Technical Letter No. 111-2-41*, Dept. of the Army, Office of the Chief of Engrs., Washington, D. C., May 1968.

317-07111-850-13

MODEL STUDY OF FISHWAY DIFFUSER FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-05070 for description of project. Adult fish will be attracted into a collection channel leading to a holding pool from which they will be transported to a hatchery, to the reservoir, or to another stream. Water for operation of the fish facilities will be pumped from tailwater, and distributed by means of six diffusion chambers into the collection system holding pool, and hopper pool. A typical diffusion chamber and portions of the adjoining supply conduit and collection channel were reproduced in a 1:10-scale model. Flow in the conduit varied from 100 to 480 cfs, diffuser discharge was 60 cfs, and a differential head of 2.5 feet existed between the supply conduit and collection channel. The purposes of the study were to check the adequacy of a typical diffusion chamber and to develop revisions if required.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

317-07112-850-13

MODEL STUDY OF HATCHERY JET HEADER FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-05070 for description of project. A new type of rearing pond, developed by the U. S. Fish and Wildlife Service, will be adapted for use at the Dworshak fish hatchery. Circulation in each pond will be provided by two jet headers that discharge between 70 and 400 gpm (0.17 to 0.89 cfs). One header, constructed full-scale of aluminum pipe, was attached to an existing water supply, tank, and weir box. The purpose of the study was to determine head-discharge relations and jet velocities for 1-1/4 and 1-inch nozzles.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

317-07114-850-13

MODEL STUDY OF REVISIONS FOR FISH LADDERS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-02662 for description of project. Based on tests in a previous model (3578 in 1970 issue of HRUSC), an 18-pool submerged orifice regulating section was developed for the north fish ladder. The design incorporated a horizontal counting station between the fixed weir and regulating sections. A similar type of regulating section was used in the south ladder; a vertical-board-type counting station was located in the sloping portion of the ladder. Difficulties with passage of fish (especially shad) led to studies of vertical-slot regulating sections for both the north and south ladders. A 1:10-scale model was used for tests of 23 pools of the north fish ladder and then the exit, regulating section, auxiliary water diffusion chamber, fish counting station, and eight typical pools downstream from counting station. The model was used to check proposed revisions and to develop modifications if required. Similar tests were made for the south ladder where the design differed from the north ladder.
(*f*) Tests completed; final report in preparation.
(*g*) A new, very effective design of vertical-slot regulating section incorporating twice the usual number of pools with a maximum water surface drop of 6 in. per pool was developed. After full-scale test of six pools with fish in the National Marine Fisheries Service Laboratory, North Bonneville, Wash., the south ladder at John Day was modified to this design. After a full season of very successful fish passage, the north ladder also was revised.

317-07115-330-13

MODEL STUDY OF NAVIGATION LOCK FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-02662 for description of project. The 86- by 675-foot lock chamber, culvert system, and portions of adjacent approach channels were reproduced in a 1:25-scale model. The purpose of the study was to determine the most advantageous design for the filling and emptying system from the standpoints of rate of operation, degree of turbulence, and economy.
(*f*) Completed.
(*h*) **Filling and Emptying System, John Day Lock, Columbia River, Oregon and Washington,** A. J. Chanda, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 98-1*, July 1974.

317-07116-350-13

MODEL STUDY OF SPILLWAY FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-02662 for description of project. A three-bay section of the 20-bay spillway and stilling basin was reproduced to a scale of 1:41.143. In supplemental investigations, two low spillway bays (diversion stage of construction), a section of stilling basin, and portions of adjacent river channel were reproduced in a 1:24-scale model. The purposes of the tests were to check original and modified designs for the spillway and stilling basin.
(*f*) Completed.
(*h*) **Spillway and Stilling Basin, John Day Dam, Columbia River, Oregon and Washington,** L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 97-1*, Nov. 1974.

317-07117-350-13

MODEL STUDY OF SPILLWAY FOR LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) Libby Dam, at Kootenai River mile 219, 17 miles upstream from Libby, Montana, will include a spillway with two 48-ft wide bays with crests at elevation 2405, three 10- by 17-ft regulating outlets, and a powerhouse for eight Francis units (ultimate installation 840,000 kW). Three powerhouse units (total capacity 315,000 kW) will be installed initially. At maximum pool elevation 2459, spillway capacity will be 145,000 cfs and total capacity of regulating outlets will be 61,000 cfs. The 116- by 300-ft stilling basin, at elevation 2073, is designed for a maximum spillway discharge of 50,000 cfs. A 1:50-scale model reproduced a portion of the forebay, all hydraulic elements of the spillway and powerhouse, and 1600 ft of exit channel. The initial purpose of the model was to check the adequacy of the spillway, regulating outlets, stilling basin, and excavated outlet channels. The scope of the study was increased to include tests of diversion plans and flow conditions with a powerhouse selective withdrawal structure.
(*f*) Tests completed; final report in preparation.
(*g*) The model tests showed that the original spillway abutments, center pier, chute, and stilling basin were not satisfactory. During development tests, the bulkhead slots and upstream projections of pier and abutments were eliminated and the circular abutments were changed to elliptical. The center pier was narrowed from 24 to 20 ft, and both sides of the pier were tapered. A tapered extension of the center pier was used to reduce undesirable rooster tail in flow down the chute. The original stilling basin was 120 ft wide and 172.8 ft long at elevation 2074, and the basin walls were at elevation 2127. The adopted basin is 116 ft wide, 300 ft long, at elevation 2073, and the sidewalls are at elevation 2142. Sizes of rock needed for riprap in exit areas were determined. Six diversion plans were studied before an acceptable plan was selected. Several types of deflectors to prevent debris from lodging against the legs of a contractor's tower were investigated for flows greater than 50,000 cfs during second-stage construction. The adopted plan consisted of two concrete piers 15 ft high and 87 ft long. Each pier acted as a deflector and later would become part of the mass concrete monolith. Tests of the selective withdrawal structures indicated that overflow bulkheads on the face of the intake must be submerged about 20 feet to supply the turbine unit flow of 5800 cfs at pool elevation 2459. The pier nose shapes were revised and a floating skimmer device was developed to prevent vortex action and air entrainment at intakes of the selective withdrawal structure. Scheduled studies with flow into a single powerhouse unit from a density-stratified reservoir have been completed.

317-07118-350-13

MODEL STUDY OF OUTLET WORKS FOR LOST CREEK DAM, ROGUE RIVER, OREGON

(*b*) U. S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) Lost Creek Dam on the Rogue River will provide 315,000 acre-feet of usable storage for flood control and other uses and 49,000 kW of electric power. A multiple-use intake

tower with openings at four levels will lead to a 15-foot diameter penstock and to a 12.5-foot diameter regulating outlet. A 6- by 12-foot bypass will permit reservoir releases through the penstock when the intake tower is unwatered. The spillway will include three 45-foot bays. Design discharges are as follows: outlets works 9860 cfs at minimum pool elevation 1812, and 11,460 at maximum pool elevation 1872; bypass 2000 cfs; spillway 158,000 cfs. A 1:40-scale model reproduced a portion of forebay, the multiport intake tower, regulating outlet intake valve section, conduit and chute, stilling basin, penstock intake and curve, powerhouse, and a section of downstream channel. Flow conditions and pressures in the tower bypass system were studied in a separate 1:40 scale model. The purposes of the study were to investigate flow conditions and pressures in the intake tower, regulating outlet, and penstock; to measure discharges through the regulating valves and bypass intake; and to check performance of energy dissipator, tailrace, and downstream channel.

(*f*) Tests completed; final report in preparation.

(*g*) Flow conditions and pressures at the intakes of both models were satisfactory. An 80 ft long section of chute walls of original design was overtopped as much as 3 ft during the chute design discharge of 12,000 cfs. The stilling basin was adequate from a hydraulic standpoint. However, the air entrainment and resulting nitrogen supersaturation downstream from this type of basin were not acceptable. Tests indicated that an alternative design with revised chute and a 30-degree, 50-ft radius flip bucket would be satisfactory. Wave suppressors 4 ft wide by 8 ft long were required on the chute walls to prevent overtopping.

317-07119-850-13

MODEL STUDY OF FISH LADDER FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 317-05071 for description of project. The 1:10-scale model included weirs at the upper end of the 20-foot wide, 1-on-10 slope ladder, followed in turn by a 17-foot long diffuser pool, the 1-on-32 slope regulating section with 10 orifice and slot bulkheads on 16-foot centers, the 6-foot wide exit channel, and a section of forebay. The purposes of the investigation were to determine the adequacy of the proposed orifice-slot control section and to develop improvements if required.

(*f*) Tests completed; final report in preparation.

(*g*) See 1970 issue.

317-07120-350-13

MODEL STUDY OF SPILLWAY FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 317-05071 for description of project. The 1:42.47-scale model included a 3-bay section of the 8-bay spillway, stilling basin, and approach channels. The study was expanded to include the hydraulic characteristics of horizontal deflectors with and without dentates on the spillway ogee. These devices may reduce nitrogen supersaturation by causing air entrained by small to moderate spillway discharges to remain near the water surface in the stilling basin. The purposes of the model are to check designs for the spillway crest, piers and abutments, chute, stilling basin, excavated channel, deflectors on the spillway ogee, and to develop revisions if required.

(*f*) Tests completed; final report in preparation.

(*g*) No revisions of the original crest and piers were required. Discharge rating curves for both free and gated flows were obtained. Satisfactory agreement was not obtained between tailwater-jump curves measured in the spillway model and in the general model (study 5071). Return flow into the stilling basin from the powerhouse tailrace and expansion of flow along the lower lock guard wall were responsible for the differences. The final design for the stilling basin will be based on tests in the general model. Tests in the spillway and general models indicate that a 12.5-foot wide horizontal deflector at elevation 630 (crest elevation 681) will produce desired stable, shallowly aerated, "skimming flow" in the stilling basin for spillway discharge 10,000 cfs per bay. Skimming action was improved by adding three rows of 1.8- by 2.6-ft dentates to ogee and deflector. Pressures on the deflector were positive. Cavitation may develop on the dentates. Use of deflectors and dentates does not reduce the energy dissipating capability of the stilling basin at high flows.

317-07121-330-13

MODEL STUDY OF NAVIGATION LOCK FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental for design.

(*e*) See 317-05071 for description of project. In the unusual hydraulic system, a central junction chamber connects both longitudinal culverts to eight symmetrically-located longitudinal port manifolds (four upstream and four downstream) in the floor of the lock. There are six pairs of ports in each manifold. A 1:25-scale model reproduced a portion of the forebay and floating guide wall, the hydraulic system, the lock chamber, and portions of exit areas and downstream approach. The purposes of the investigation were to check the adequacy of the proposed design and to develop modifications if required.

(*f*) Tests completed; final report in preparation.

(*g*) See 1970 issue.

317-07122-850-13

MODEL STUDY OF FISH LADDERS FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 317-03577 for description of project. Each of the two fish ladders is 16 feet wide and is constructed with a floor slope of 1 on 10. The partial overflow weirs are 6 feet high, have a 6-foot long baffle or nonoverflow section in the center, and have two 18- by 18-inch orifices at the floor. A 55-pool tangent portion of the proposed fish ladder was reproduced in a 1:10-scale model to obtain discharge data, to check flow stability, flow patterns, and velocities, and to develop revisions if needed.

(*f*) Completed.

(*h*) **Fish Ladders for Lower Monumental Dam, Snake River, Washington,** L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 109-1*, Dec. 1973.

317-07123-330-13

MODEL STUDY OF NAVIGATION LOCK FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.

(*d*) See 317-03577 for description of project. Except for the intake manifolds, which are staggered in the upstream channel, essential features of the hydraulic system are similar to those previously model-tested and adopted for use at John Day Dam. The 1:25-scale John Day lock model was revised for this study by using the longitudinal culvert intake (John Day elevation 114 = Lower Monumental elevation 396) for elevation control, installing new upstream culvert transition and intake manifolds, and lowering the approach floor 4 feet for correct depth at intakes. The main purpose of the model study was to obtain acceptable flow conditions (no vortex formation) over the intake manifolds. Pressures in the culvert and hydraulic loads on a proposed revision of the lock emptying valves (skin plate upstream) were measured in the Lower Granite lock model.

(*f*) Tests completed; final report in preparation.

(*g*) See 1970 issue.

317-08441-850-13

MODEL STUDY OF FISH LADDER MODIFICATIONS AT BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 317-07107 for description of project. The upstream portions of existing fish ladders must be modified to accomodate daily forebay fluctuations due to future upriver power peaking and operation of additional power units at Bonneville Dam. The purpose of the study is to investigate in a 1:14-scale model the hydraulic operation of exit control sections, counting and public viewing sections, auxiliary water-supply intakes and conduits, and revised overflow weirs in the Bradford Island and Washington Shore fish ladders.
(*f*) Completed.
(*h*) **Modification of Fish Ladders, Bonneville Dam, Columbia River, Oregon and Washington**, P. M. Smith, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 141-1*, Dec. 1973.

317-08442-850-13

FISH HATCHERY AERATOR AND DEAERATOR TESTS

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Filtered water, aerated, deaerated, and temperature regulated, will be recirculated through systems of headers and nozzles into rearing and holding ponds of several fish hatcheries that are being installed by the Corps of Engineers. Each pair of nozzles is designed to discharge 250 gpm (125 gpm per nozzle). One bank of 28 pairs of aerator nozzles (total discharge 7000 gpm) will be supplied by a 16-inch header pipe. Another bank of 16 nozzles (4000 gpm) will be supplied by a 12-inch header. Two banks of deaerators will be supplied by 6- and 8-inch headers (respective discharges 750 and 1000 gpm). Equal pressures are desired in both sets of headers. The purpose of the investigation was to calibrate aerator and deaerator systems of commercial black iron and PVC plastic pipe.
(*f*) Tests completed; final report in preparation.
(*g*) Pressures, discharges, and air demands were measured for four sizes of aerator pipe. Pressures and discharges were determined for four sizes of deaerator pipe.

317-08443-350-13

MODEL TESTS OF RELIEF PANEL FOR SELECTIVE WITHDRAWAL GATES AT DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-05070 for description of project. Selector gates of the multi-level power intakes will have 90 pressure relief panels per power intake to protect the gates against failure from internal waterhammer or excessive differential pressures caused by misoperation of the gates or power units. The panels will consist of butterfly valves mounted on torsion bars. A 1:5-scale model was used to determine torque on the shaft of a 1- by 4-foot panel and discharge for various openings under differential heads of 3 to 20 feet. The data were needed to verify and supplement design computation.
(*f*) Tests completed.
(*g*) Torque and discharge were measured for panel openings of 10, 20, 30, 40, and 45 degrees and heads of approximately 3 to 20 feet. Torque decreased with panel opening until a negative value was reached at an opening of 47 degrees. The maximum torque, 1869 foot-pounds, was measured at a differential head of 18.37 feet and a panel opening of 10 degrees.

317-08444-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-05071 for description of project. A 1:40-scale model reproduced a proposed powerhouse skeleton unit and sections of approach and exit channel. The study was to determine the maximum discharge as limited structurally that could be released through a unit without entraining air and causing or increasing nitrogen supersaturation of flow passing the project, and the best method of controlling the discharge.
(*f*) Tests completed; final report in preparation.
(*g*) Initially, the operating gates were tested as flow controls. Then the gates in combination with stoplogs in the gate and intake slots were investigated. From these studies, a bulkhead with slots or converging tubes was developed for prototype tests in a similar unit at Little Goose Dam during the spring freshet in 1971. Slots in the top seven rows were 4 inches high; the lower eight slots were 6 inches high (area 95 sq. ft.). The slot tubes converged on slopes of 1 on 4.27 and 1 on 4.78, respectively. The skeleton unit discharged 21,200 cfs (discharge coefficient 0.932) under 99 feet of head between forebay and tailwater. Positive pressures were measured within the converging tubes and on the piers at the operating gate slots. Flow conditions within the skeleton bay were turbulent but satisfactory. Full-height, 12-inch deflectors attached to the left faces of intake piers reduced upwelling in the left downstream corner of the bay. Measurements at Little Goose Dam showed no increase in nitrogen supersaturation in flow downstream from a bulkhead skeleton unit. Discharges were measured and flow conditions were determined with and without slotted bulkheads upstream from partially-completed units with scroll case and wicket gates installed.

317-08445-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-00405 for description of project. The purpose of the study was to develp a satisfactory design for slotted bulkheads which would allow passage of the maximum flow through a skeleton unit without entraining air. Entrained air would cause or increase nitrogen supersaturation of flow passing the project. A 1:40-scale model reproduced an existing powerhouse skeleton unit and sections of approach and exit channel.
(*f*) Tests completed; final report in preparation.
(*g*) The original bulkhead design, which was based on the design developed in the Lower Granite skeleton unit model (317-08444), was not satisfactory when tested in the Ice Harbor model because of submergence differences. An alternative plan with three 8-inch, four 6-inch, and five 4-inch slots (bottom to top, area 84.5 sq. ft.), provided satisfactory control of turbulence and aeration and a discharge of 19,200 cfs per unit. Nearly unrestricted movement of operating gates when activating or deactivating the skeleton unit was possible.

317-08446-350-13

MODEL STUDY OF ORIFICE BULKHEADS FOR POWERHOUSE SKELETON UNITS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-02662 for description of project. The purpose of the study was to develop a design for orifices in bulkheads to control discharges through skeleton powerhouse units without air entrainment that would increase nitrogen supersaturation below the dam. These skeleton units differ from those tested for other projects in that more concrete was added to the turbine bays. A final stage skeleton unit and sections of approach and discharge channels were tested in a 1:40-scale model.
(*f*) Completed; final report in preparation.
(*g*) Modifications tested included a temporary roof over the turbine bay, a partition on the intake roofs, and slotted bulkheads in the intake bays. Tests were made on four

plans with a bulkhead in all three intakes and on seven plans with a bulkhead in the center intake only (no flow through the other intakes). Although conditions with the temporary roof and three bulkheads were acceptable, these modifications would be very costly. With a single bulkhead, heads on interior walls, pressures on the bulkhead, and air entrainment were excessive.

317-08447-350-13

MODEL STUDY OF SPILLWAY FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Develop spillway flow deflectors that will produce stable "skimming flow" in the stilling basin, reduce deep air penetration and nitrogen supersaturation, and still allow good energy dissipation at high discharges. A three-bay section of upstream approach, spillway, stilling basin, and downstream channel were reproduced in a 1:42.47-scale model.
(*f*) Completed; final report in preparation.
(*g*) Air pentration, flow directions and flow stability in the stilling basin were observed with and without deflectors on the spillway chute. Without deflectors, flows of 5,175 to 15,000 cfs per bay carried large amounts of entrained air to the invert of the stilling basin. Three lengths of deflectors (15, 12.5, and 10 ft) were tested for discharges of 2,560 to 106,250 cfs per bay. The best design, a 12.5-ft deflector at elevation 434, provided stable skimming flow for river discharges to 251,000 cfs (15,000 cfs per bay with flow through six powerhouse units). These deflectors did not reduce stilling basin capacity at higher flows. Three rows of 1.8-ft-wide by 2.6-ft-high dentates located on and just upstream from the deflectors further reduced air penetration and stabilized flow in the stilling basin. Tests in one prototype bay in 1972 indicated that the deflector did reduce nitrogen supersaturation, but areas of concrete just downstream from the dentates were severely damaged by cavitation and debris. Additional tests, without dentates, were made in a general spillway model (see separate report).

317-09341-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-00405 for description of project. The purpose of the study was to develop deflectors on the spillway ogee to reduce deep air entrainment in the stilling basin and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 1:40-scale model.
(*f*) Tests completed; final report in preparation.
(*g*) Spillway discharges of 17,500 cfs or less per bay (river discharge 250,000 cfs or less) were of primary concern because these flows occur during the most important runs of fish. The best overall reduction in depth and quantity of air penetration was obtained with 12.5-ft-wide by 50-ft-long deflectors at elevation 336. With these deflectors, surging occurred in the stilling basin for spillway flows of 13,000 to 25,000 cfs per bay. Additional tests will be made in a 1:50-scale general spillway model.

317-09342-350-00

MODEL STUDY TO REDUCE NITROGEN SUPERSATURATION, LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See separate report for location of project. The study is being made to develop a structure that for normal flows will reduce dissolved nitrogen in water passing over or through the structure.
(*g*) An applied research study was begun. Supersaturated flow is passed down a baffled chute, highly aerated and agitated at atmospheric pressure, and the reduction in total dissolved gases is measured and corrected for dissolved oxygen. Three shapes and two sizes of baffles and two chute slopes have been tested. Reductions of 8 to 10 percent were obtained for a flow of 22 cfs in a chute 3.6 ft wide and 12.6 ft long with a slope of 1V on 4H. Discharge capacity and flow conditions at the chute exit will be studied in a 1:80-scale model (see separate report).

317-09343-350-13

MODEL STUDY OF PRESSURE RELIEF PANELS FOR SELECTOR GATES, LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 317-07117 for description of project. Each power unit is protected by 36 relief panels in bulkheads of the selective withdrawal structure. The purpose of the study was to assure that the proposed pressure relief panels will protect the selective withdrawal structure from excessive upstream or downstream heads caused by powerhouse load rejections or misoperations. A 1:5-scale model reproduced a 3- by 6-ft relief panel, hinged at the top, and the panel frame.
(*f*) Tests completed; final report in preparation.
(*g*) Gate position, force on the gate, and discharge were measured for prototype heads to 13 feet. Torque and discharges were observed with panel openings of 20 to 90 degrees and head differentials of 0.20 to 15.23 feet. The prototype panel would open fully to the 90-degree position under a head differential of 1.42 feet.

317-09344-350-13

MODEL STUDY TO REDUCE NITROGEN SUPERSATURATION, LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 317-07117 for description of project. The purpose of the study was to develop flow deflectors or other devices on the sluices and spillway that will allow discharge through the stilling basin with a minimum of air entrainment and nitrogen supersaturation downstream from the project. The spillway, regulating outlets, stilling basin, and portions of the forebay and tailrace were reproduced in a 1:50-scale model.
(*f*) Suspended.
(*g*) Flip buckets and deflectors below the sluice outlets and slotted bulkheads in the sluice intakes were investigated singly and in combination. Flow conditions with three short 10-degree deflectors were good for a sluice flow of 10,000 cfs and unsatisfactory at discharges higher than 20,000 cfs. None of the plans was adequate for the initial period of no power flow (present through 1975). The tests were discontinued. Nitrogen supersaturation will be reduced at a reregulating dam downstream (see separate report).

317-09345-350-00

MODEL STUDY OF LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) To investigate tailrace and downstream flow conditions during diversion and after completion of structures, to test the spillway design for flows to about 230,000 cfs, and to study possible structures for equilibration of dissolved nitrogen for discharges to 26,000 cfs and some reduction from 26,000 to 40,000 cfs. A 1:80-scale model will reproduce the Kootenai River channel and pertinent overbank topography for about one mile upstream and two miles downstream from the project axis at river mile 208.9, 11 miles below Libby Dam, and all interim and completed structures. Sectional models of the spillway and fish facilities may be required.
(*g*) Construction of the basic general model was begun.

317-09346-350-13

MODEL STUDY OF FALSE WEIR AND FISH LADDER, CHARLES RIVER, MASSACHUSETTS

(*b*) U. S. Army Engr. Division, New England.
(*e*) To check the adequacy of proposed designs for the false weir and slot-type fishway and to develop improved designs if necessary. A 1:4-scale model reproduced the false weir, inflow pipe and part of the first pool downstream from the false weir. A 1:8-scale model included the false weir, 29-pool fish ladder, diffusion chambers for attraction flow, and a section of downstream approach.
(*f*) Tests completed; final report in preparation.
(*g*) The ladder developed in the model study has 29 pools that are connected by vertical slots that provide fish passage between the entrance and a false weir with exit chute to the upstream basin. Velocities in the slots ranged from 1.1 to 7.2 fps. No upwelling that might attract or trap fish occurred along walls or in corners. Velocities over the false weir were between 4.1 and 4.9 fps, downstream discharge of the weir was 14 to 15 cfs, and discharge to the chute was 1.23 to 2.48 cfs. Attraction flow from the entrance penetrated 50 to 60 ft into tailwater.

317-09347-350-00

MODEL STUDY OF OUTLET WORKS FOR ELK CREEK DAM, ROGUE RIVER BASIN, OREGON

(*b*) U. S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The project will be located on Elk Creek, 1.7 miles upstream from the confluence of this stream with the Rogue River and about 27 miles north of Medford, Oregon. The dam will consist of a rockfill embankment 238 ft high and 2,560 ft long with a concrete gravity-type spillway in the right abutment. The outlet works include a multiple-use intake structure, two 5- by 9.5-ft discharge conduits 844 ft long, and a flip bucket. Design discharge for the spillway is 56,300 cfs and for the outlet works 6,000 cfs at minimum flood control pool elevation 1665 and 7,200 cfs at maximum pool elevation 1726. Conditions affecting fish attraction adjacent to the plunge pool and flow along bank lines downstream from the flip bucket will be studied in a 1:40-scale model.
(*g*) Design and construction of the model were completed in 1974.

317-09348-350-00

GENERAL MODEL STUDY OF CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 317-07109 for description of project. The study was made to determine the effects of spillway deflectors and ultimate 27-unit powerhouse on flow conditions in the tailrace. A section of forebay, the 19-bay spillway with piers and gates for the pool raised 10 ft to elevation 956 (bays 36 ft wide instead of as-built 40-ft bays), downstream side of 27-unit powerhouse, and tailrace to the mouth of Foster Creek were reproduced in a 1:72-scale model.
(*f*) Tests completed; final report in preparation.
(*g*) Velocities, wave heights, water-surface elevations, and overall flow conditions were observed with uniform and nonuniform spillway gate openings. River discharges of 190,000 to 1,200,000 cfs and operation of 0, 9, 18, and 27 powerhouse units were studied. With 12.5-ft-wide deflectors at elevation 775 (see separate report), wave rideup along the banks and wave heights at the powerhouse created by the deflectors was reduced by nonuniform openings of the spillway gates.

317-09349-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 317-07109 for description of project. The purpose of the study was to develop a flow deflector to produce stable "skimming flow" instead of plunging flow in the stilling basin, thereby reducing nitrogen supersaturation downstream from the spillway. A four-bay, 1:43.35-scale sectional model reproduced the existing stilling basin, exit channel, and spillway agee. The piers and gates were for the raised pool, elevation 956, with 36-ft-wide bays, rather than with as-built 40-ft bays.
(*f*) Tests completed; final report in preparation.
(*g*) A 12.5-ft-wide deflector at elevation 775 on the spillway chute provided the best overall performance. Skimming flow existed up to 14,000 cfs per bay with tailwater for 27-unit powerhouse operation, 10,000 cfs with 18-unit operation, and 6,500 cfs per bay with the powerhouse closed. Either surging or plunging flow occurred above these limits. Surging flow may increase wave action along the downstream side of the powerhouse. Deflectors on piers adjacent to ends of spillway were required to minimize overtopping of training walls. Tests of the entire structure were made in a 1:72-scale model (see separate report).

317-09350-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 317-04504 and 317-05068 for description of project. Deflectors on the spillway chute are being developed to reduce deep air entrainment in the stilling basin (roller bucket) and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel are reproduced in a 1:42.47-scale model.
(*g*) Four deflector widths and three deflector elevations have been studied with discharges of from 4,700 to 106,250 cfs per bay. Additional tests of the best design will be made in a 1:50-scale general spillway model.

317-09351-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR MCNARY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U. S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) The existing project, located about 2.5 miles upstream from Umatilla, Oregon, includes a 22-bay spillway, a 14-unit powerhouse, an 86-ft by 675-ft navigation lock with maximum single lift of 92 ft, and facilities to pass migratory fish upstream over the dam. Flow under or between upper and lower halves of the vertical-lift spillway gates carries entrained air deep into the stilling basin. This results in excessive amounts of dissolved gases (chiefly nitrogen) that are harmful to fish downstream from the project. The purpose of the tests was to develop a means of spilling flood waters without increasing nitrogen supersaturation. A 1:40-scale model reproduced a three-bay section of the forebay, spillway, stilling basin downstream from bays 1 to 19, and exit channel.
(*f*) Completed; final report in preparation.
(*g*) Air penetration, flow stability, and current directions in the stilling basin, and pressures were determined with and without deflectors. Flow was passed underneath or between upper and lower sections of the gates. Spillway discharges of 13,500 cfs and less per 50-ft bay were of primary concern. Without deflectors, flow for either method of gate operation plunged to the floor of the stilling basin; highly aerated water was distributed uniformly throughout the basin. With 12.5-ft-long horizontal deflectors at elevation 256 and discharge beneath the gates, stable "skimming flow" (with air bubbles confined to the top layer of water) occurred for an 8-ft range in tailwater elevations (257 to 265). Deflectors 20 ft long at elevation 256 were required when flow was passed between gate sections. Additional tests, with deflectors on the spillway chute, will be made in a general spillway model.

317-09352-350-13

MODEL STUDY OF OUTLET FOR MOOSE CREEK DAM, CHENA RIVER LAKES PROJECT, ALASKA

(*b*) U. S. Army Engr. Dist., Alaska.
(*d*) Experimental; for design.
(*e*) Moose Creek Dam, to be located on the Chena River about 17 miles east of Fairbanks, Alaska, will have an average height of about 30 ft and will have an overall length of 7.1 miles. The earthfill dam will divert Chena River flood waters into the Tanana River and provide non-damaging flows in the existing Chena River channel. A proposed outlet channel with riprapped bottom 80 ft wide and riprapped side slopes of 1V on 2H will divert the river from its natural channel upstream of the dam, through the outlet structure, and back to the river downstream from the dam. The outlet works was sized to pass river flows up to 9,000 cfs, small recreation boats, and fish underneath four 25- by 18-ft vertical-lift gates. Two fishways and a fish ladder are proposed for use when velocities through open gate bays exceed 2.5 fps and when flows are being regulated. The purposes of the model study are to check hydraulic performance of the proposed design and to develop revisions if required.
(*g*) Tests in a 1:20-scale model of one gate bay and appropriate lengths of approach and exit channel were completed. Flow conditions with the intial plan in a 1:40-scale comprehensive model that reproduces about 8,600 ft of river channel were observed.

DEPARTMENT OF THE ARMY, WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, P. O. Box 631, Vicksburg, Miss. 39181. F. R. Brown, Engineer, Technical Director.

These project summaries are abridged from more detailed descriptions appearing in the FY 1975 Civil Works Annual Research Summary, Vol. 2, Office Chief of Engineers, Washington, D. C. 20314.

318-04390-330-13

MODEL STUDY OF CANNELTON LOCKS AND DAM, OHIO RIVER

(*b*) Ohio River Division, Louisville.
(*c*) S. T. Mattingly.
(*e*) Investigate navigation conditions in the lock approaches and effects of the structures on flood stages; to obtain data for development of rating curves; and to determine the effect of powerhouse installation on flow and navigation conditions.
(*g*) The study was made with a 1:120-scale model reproducing about nine miles of the river and sufficient overbank areas to permit the reproduction and study of flows up to the maximum of record (1937 flood). The model included the locks and dam structures with provisions for the installation of powerhouse facilities. Also, 20 piezometer-type gages were provided to permit study of swellheads as affected by the locks and dam and the powerhouse facilities.

318-05246-330-13

UNIONTOWN LOCKS AND DAM

(*b*) Ohio River Division, Louisville.
(*c*) R. T. Wooley.
(*e*) Investigate navigation conditions in the lock approaches, the location of the locks, and the distribution of flow around Wabash Island.
(*g*) The model was of the fixed-bed type, constructed to an undistorted scale ratio of 1:120, and reproduced about 8.5 miles of the Ohio River between miles 842 and 851, along with adjacent overbank areas, Wabash Island, back channel, the locks and dam structures, and the mouth of the Wabash River.

318-06849-400-13

MODEL STUDY OF CHESAPEAKE BAY

(*b*) Baltimore District, North Atlantic Division.
(*c*) David Bastian, Estuaries Branch.
(*e*) The Estuaries Branch has been given the responsibility for assisting the Baltimore District in the design, construction, verification, and testing of a hydraulic model of the Chesapeake Bay. The model will be utilized to develop a water-land management plan for use of the Chesapeake Bay and tributaries. A fixed-bed, comprehensive model of the Chesapeake Bay and tributaries with linear scale ratios of 1:100 vertically and 1:1000 horizontally will be constructed. The model will have the capability of reproducing tides, current velocities, salinities, hurricane surges, and freshwater inflows.
(*g*) Initiated construction of the hydraulic model in October 1974.

318-06859-330-13

MODEL STUDY OF SMITHFIELD LOCK AND DAM

(*b*) Ohio River Division, Nashville.
(*c*) B. K. Melton.
(*e*) Determine the suitability of the location of proposed locks and dam from a navigation standpoint and to develop plans for the elimination or reduction of shoaling in approach channels. The study was conducted on a 1:150-scale model extending from river mile 916.5 to 925.0 which was convertible from fixed bed for navigation studies to coal bed for channel development studies.

318-07163-410-13

NAVIGATION CHANNEL IMPROVEMENTS, BARNEGAT INLET, NEW JERSEY

(*b*) North Atlantic Division, Philadelphia District.
(*c*) R. A. Sager.
(*e*) Investigate the feasibility of plans for improving navigation at Barnegat Inlet. A fixed-bed model that was later converted to a movable-bed model was used for the study. The model reproduced the Barnegat Inlet and immediate surrounding ocean and bay and was constructed to a scale of 1:60 vertically and 1:300 horizontally. Tidal flows from the ocean and bay were reproduced at the respective ends of the model.
(*f*) Completed.
(*g*) Plans for inlet stabilization by jetty construction, jetty modification, and other improvements were studied, and the effects of proposed improvements on normal tides in the bay and velocities in the inlet were investigated. The optimum length and location of jetty improvements were developed. Dredging patterns were developed during model tests, and their effects on navigation conditions in the inlet were evaluated.
This report was completed and published March 1974. The total cost was $12,347.00.

318-07171-470-13

INVESTIGATION OF SHOALING AT HARBOR ENTRANCES

(*b*) Lower Mississippi Valley Division.
(*c*) B. K. Melton.
(*e*) Conduct a study of shoaling at harbor entrance in alluvial streams under laboratory conditions to determine corrective measures to be taken at St. Louis, Mo., Greenville, Miss., and Lake Providence, La. The study was conducted in a movable-bed model in which the harbor entrances were modified to fit existing conditions or in accordance with proposed plans.
(*h*) Report in process.

318-08645-330-10

GALLIPOLIS LOCKS AND DAM

(*b*) Ohio River Division, Huntington.
(*c*) R. T. Wooley.

(*e*) Investigate the feasibility of modifying the existing structures and to compare the advantages and disadvantages of a replacement structure downstream. Two models of the fixed-bed type have been used to investigate conditions at the existing site and at an alternate site about three miles downstream. The models are constructed to a scale of 1:120 and reproduce the Ohio River and adjacent overbanks from about river mile 276 (Racoon Creek) to 284 (Eighteen Mile Creek) including the existing locks and dam at mile 279.2 and the proposed new site at mile 282.3.

318-09663-820-13

ANALYSIS OF ARBITRARY WELL SYSTEM

(*b*) Lower Mississippi Valley Division.
(*c*) J. B. Warriner.
(*e*) Formalize the results as have been previously obtained from electrical analog model studies into a computer program, accompanied by example problems and a fully documented user guide, that can give the designer the capability of predicting flow and drawdown associated with fully and partially penetrating wells placed arbitrarily within irregular boundaries. This work is being performed to aid in the design of numerous construction dewatering systems for projects in LMVD. A complete review of the results previously obtained for single wells will be performed, followed by an extension of the results to multiple well systems. An existing computer will be modified to include the results of the review and then used to check specially designed electrical analog tests.
(*g*) A technique has been devised for calculating discharges from wells of random spacing and different locations.
(*h*) Report in preparation.

318-09664-710-13

EVALUATION OF REMOTE IMAGERY TYPES FOR IDENTIFYING SELECTED FLOODPLAIN CHARACTERISTICS

(*b*) Lower Mississippi Valley Division.
(*c*) J. H. Shamburger.
(*e*) Evaluate the potential of color infrared and thermal infrared remote imageries flown in March and April 1973 to determine specific characteristics of the Mississippi River and its floodplain. These characteristics are levee seepage, sediment concentration, flow patterns, bank stability, geological data, and present river alignment versus natural geometry. All ground truth data have been collected and plotted on topographic maps. The imagery has been examined and evaluated.
(*h*) Report in process.

318-09665-390-13

INVESTIGATION OF THE RESISTANCE OF FRESHLY INJECTED GROUT TO EROSION AND DILUTION BY FLOWING WATER

(*b*) Lower Mississippi Valley Division.
(*c*) D. M. Walley.
(*e*) Improve the resistance of portland-cement grouts to erosion and dilution when freshly emplaced in various velocities of flowing water. This investigation is directed toward the possible need for such improved grouts for rehabilitation of Old River Low Sill Structure, L&D 25, and other structures where scour beneath the structure may develop and require grouting. The approach will entail using a transparent flume (16 ft long, 1 ft wide, and 4 ft high) into which grout mixtures will be injected. A variety of formulated portland-cement grouts containing additives will be tested and determination of their resistance to erosion and dilution by various velocities of water flow in the flume will be made.

318-09666-830-13

LEVEE WAVE WASH PROTECTION

(*b*) Lower Mississippi Valley Division.
(*c*) James P. Sale.
(*e*) Determine the suitability of dust-control agent DCA-1295 as a temporary wave protection on the riverside slopes of levees during flood periods when the slopes are subjected to wave action. A typical levee slope (1 on 3) will be constructed in a hydraulic wave flume using silty clay soil. The wave machine will be calibrated to produce desired wave patterns, and the unprotected clay slope will be subjected to such wave action. The clay will then be treated with the DCA-1295 and tested to determine the most effective application rate. Natural slopes will also be treated with DCA-1295 to determine the effects of vegetation on the spray material.
(*g*) The 1 on 3 clay slope has been constructed in the wave flume, and the wave machine has been calibrated to produce the desired pattern. One test has been conducted without any slope protection and one test has been made with the clay sprayed with DCA-1295 at a rate of 3 lb. per sq. yd. Six areas of a natural slope (with vegetation) have been treated with the DCA-1295.

318-09667-330-13

LOCK AND DAM 26, MISSISSIPPI RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) R. T. Wooley.
(*e*) Determine whether the existing structure should be modernized by adding an additional lock or whether a new structure should be provided. A model study is being conducted which encompasses the reach between river miles 199.0 and 205.7 on the Mississippi River, and the model is built to an undistorted scale of 1:120. The model is of the fixed-bed type reproducing locks and dam structures and adjacent overbank area between the levees.

318-09668-350-13

LOW DAM REPLACEMTNT, CAHOKIA CREEK DIVERSION CHANNEL

(*b*) Lower Mississippi Valley Division.
(*c*) J. H. Ables, Jr.
(*e*) During 1970, a model study was conducted on the subject project with a trapezoidal ogee spillway and a trapezoidal stilling basin. A satisfactory design was developed. The design was changed from trapezoidal to rectangular. The length of the horizontal crest remained the same (188 ft) and there was concern that, due to the higher concentration of energy, the basin would not maintain a hydraulic jump with design discharge of 62,000 cfs and minimum tailwater of 400 ft elevation. The effect on the riprapped scour hole of design tailwater and of lower tailwater elevations was to be determined. A 1:50-scale model reproducing an approach 600 ft long by 1000 ft wide, the spillway, and an exit area 700 ft long by 700 ft wide was used to evaluate and refine the proposed design.
(*f*) Completed.
(*g*) The stilling basin as originally designed did not maintain a jump in the basin with minimum tailwater. A satisfactory design was developed that provided good performance with all discharges up to 40,000 cfs and maintained a hydraulic jump under design flow (62,00 cfs) and minimum tailwater conditions (elevation 398). Riprap requirements downstream from the basin were determined.

318-09669-300-13

MISSISSIPPI BASIN MODEL – ATCHAFALAYA BASIN TEST

(*b*) Lower Mississippi Valley Division.
(*c*) J. V. Allen.
(*e*) Study the effects of dredging a central channel in the Atchafalaya River Basin to a minimum cross-sectional area of 100,000 sq. ft. and the effects of sedimentation in the basin. The approach is to adjust the model to 1969 conditions and conduct a series of tests of hydrograph flows and steady flows; install the 100,000 sq. ft. channel with the accompanying spoil fills and sedimentation and repeat the tests; and then install additional sedimentation and repeat the tests.
(*f*) Completed.

(*h*) Mississippi Basin Model Report 81-5; was transmitted to New Orleans District, Jan. 1974.

318-09670-300-13

MISSISSIPPI RIVER PASSES MODEL STUDY

(*b*) New Orleans District; Lower Mississippi Valley Division.
(*c*) G. M. Fisackerly.
(*e*) Investigate plans for the reduction of shoaling in the existing 40-ft channel and determine the feasibility of a deeper channel. A fixed-bed model reproduces the Mississippi River downstream from 14 miles above Head of Passes, including South and Southwest Passes and portions of Pass a Loutre and Cubits Gap and a segment of the Gulf of Mexico. Model scales are 1:100 vertically and 1:500 horizontally. Fixed-bed shoaling tests using artificial sediments will be used to evaluate improvement plans.
(*g*) The model has been verified for hydraulics and for sedimentation in the Head of Passes area.

318-09671-330-13

MODEL STUDY OF ALEXANDRIA REACH, RED RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) R. T. Wooley.
(*e*) Determine the modification required to bridges in the reach and the type and location of regulating structures required to develop a satisfactory navigation channel through the reach. An undistorted fixed-bed model has been constructed to a scale of 1:100, model to prototype. The model encompasses about four miles of the river channel including the five bridges through the reach as well as adjacent overbank areas between levees.
(*g*) Tests in progress.

318-09672-330-13

MODEL STUDY OF EMERGENCY BULKHEAD CLOSURE, MISSISSIPPI RIVER GULF OUTLET LOCK

(*b*) Lower Mississippi Valley Division.
(*c*) J. H. Ables, Jr.
(*e*) Study design details and the plan for emergency closure of the 150-ft-wide and 1200-ft-long lock. A 1:50-scale model will be used to reproduce the entire chamber and an appropriate length of canal at each end. The bulkheads will be reproduced accurately to scale, size, shape, and weight. One pair of miter gates may be accurately reproduced to scale so that the possibility of their use for emergency closure can be tested. Model tests will be concerned with determining loads acting on the closure during emergency placement. The problem will be unusual due to the width of the lock being 40 ft greater than closures previously studied.

318-09673-330-13

MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR MISSISSIPPI RIVER-GULF OUTLET LOCK

(*b*) Lower Mississippi Valley Division.
(*c*) J. H. Ables, Jr.
(*e*) Develop a side wall port filling and emptying system for lockage of both barge and ship traffic. All elements of the system must be adequate under normal and reverse head conditions common to the proposed site. A 1:25-scale physical model that reproduces portions of the upper and lower approaches and the entire filling and emptying system is being used for study and evaluation of performance of the proposed 150-ft-wide and 1290-ft-long lock chamber. Barge tows and ships of variable drafts are simulated as well as the usual culvert valve control equipment and instrumentation to measure hawser forces.
(*g*) A satisfactory design was developed for barge tows consisting of 12, 18 and 24 barges with a 12-ft-draft and a maximum displacement of 65,000 tons. Tests with a 140-ft-wide and 900-ft-long ship with drafts of 30-, 37.5- and 45-ft indicated that the clearance provided beneath the ship with a 45-ft draft was insufficient to fill and empty in a reasonable time with allowable hawser forces. Tests with additional clearances are in progress to determine the feasibility of lowering the elevation of the proposed system between the miter gates.

318-09674-350-13

MODEL STUDY OF MERAMEC PARK RESERVOIR OUTLET WORKS

(*b*) Lower Mississippi Valley Division.
(*c*) J. P. Bohan.
(*e*) Evaluate the performance of the outlet works and stilling basin for the expected range of discharges and to determine the size and extent of stone protection required in the exit channel. Tests will be conducted in a 1:40-scale model simulating a 250-ft-wide and 400-ft-long approach area, a schematic representation of the intake structure, the transition, conduit, stilling basin and 1000 ft of exit channel. Piezometers will be placed in the conduit to measure pressures, and photographs indicating hydraulic performance at various flow rates will be presented.

318-09675-330-13

MODEL STUDY OF PROPOSED DIKE SYSTEMS (ISLAND 63, MISSISSIPPI RIVER)

(*b*) Lower Mississippi Valley Division.
(*c*) C. R. Nickles.
(*e*) Determine the effectiveness of proposed dike plans in stabilizing low water channels and in providing the required increase in depth for navigation. The study is being conducted in a 150-ft-long flume with a varying width from 30 to 90 feet. The model is of the movable-bed type with a fine, uniform sand used for bed material.

318-09676-350-13

MODEL STUDY OF RED RIVER SPILLWAYS NOS. 1 AND 2

(*b*) Lower Mississippi Valley Division.
(*c*) N. R. Oswalt.
(*e*) Assist in design of the subject spillways and determine the size and extent of downstream riprap protection required with single-gated operations. A 1:36-scale hydraulic model reproducing about 600 ft of the approach area, the full width of spillway, and 1400 ft of the exit channel was used to evaluate and refine the proposed designs.
(*g*) The optimum stilling basin elevations and baffle pier arrangement, minimum basin lengths and minimum downstream riprap requirements were obtained for both one-half and fully opened single gated operations on spillways Nos. 1 and 2.

318-09677-330-13

MODEL STUDY OF SHOALING IN SAWYER BEND AND ENTRANCE TO CHAIN OF ROCKS CANAL (MISSISSIPPI RIVER)

(*b*) Lower Mississippi Valley Division.
(*c*) S. T. Mattingly.
(*e*) Investigate various plans to eliminate shoaling in Sawyer Bend and improve shoaling conditions in the lower entrance to Chain of Rocks Canal. A movable-bed model with scale ratios of 1:250 horizontally and 1:100 vertically reproducing the Mississippi River from about river mile 169.0 to 190.8 is being used for the study.

318-09678-330-13

MODIFICATION OF INLAND WATERWAYS SIMULATION MODEL FOR THE GULF INTRACOASTAL WATERWAY

(*b*) New Orleans District.
(*c*) L. L. Daggett.
(*e*) Modify NCD-PSU Inland Waterways Simulation Model for application to the Gulf Intracoastal Waterway. Modifications include the options of consecutive unidirectional lockage (NUMD), multiple tow lockage (MULTI), and open pass lockage (OPEN). The logic for modifying the locking routine in the waterway simulation model to accomplish the above stated options, in addition to those

previously existing, was determined and tested. The portion of the program involving the lockage processing was then rewritten and debugged. The final version was then placed in the total model program and further tested and debugged. Finally, the revised version was tested using a portion of the GIWW as the prototype. This required preparation of calibration and model data.

(*h*) **WATSIM IV Logic Manual,** *Miscellaneous Paper* and, **Determination of Summary Statistics of Lock Performance Using the Lock Data Analysis Program: LOKDAP,** *Miscellaneous Paper H-74-6*, May 1974.

318-09679-350-13

OLD RIVER CONTROL STRUCTURE, VIBRATION MEASUREMENTS

(*b*) Lower Mississippi Valley Division.
(*c*) E. B. Pickett.
(*e*) Monitor structural vibration during high (flood) flows and during demolition (using explosives) activities. Structural accelerations, water shock pressures, and soil velocities were measured; these data were relayed to District personnel at the site during the emergency operations. The data describe the motion of a massive concrete structure under two notable types of dynamic loadings and are being retained for subsequent analysis if required.

318-09680-350-00

OLD RIVER DIVERSION MODEL STUDY

(*b*) Lower Mississippi Valley Division.
(*c*) Captain J. R. Sargeant.
(*e*) Obtain data to permit development of plans for the repair of damages that occurred to the low-sill structure during the 1973 flood and to aid in the selection of a site for another low-sill structure. Initially the study was conducted on a 1:120 scale, fixed-bed model from Mississippi River mile 313.0 to 318.5. Subsequently, the model was extended downstream to mile 306.0.
(*g*) Tests requested on the existing structures have been completed. Tests to determine the location of a new low-sill structure have been completed. Tests to develop plans which would improve flow conditions at the new Old River Diversion Channel entrance have been completed. Plans are being undertaken to revise the model to a 1974 channel survey.

318-09681-330-13

RED RIVER WATERWAY, LOCK AND DAM NO. 1 MODEL STUDY

(*b*) Lower Mississippi Valley Division.
(*c*) C. R. O'Dell.
(*e*) Investigate alignment problems and the effectiveness of training works needed to satisfy navigation conditions and requirements in the vicinity of the proposed cutoff and lock. A movable-bed model with scale ratios of 1:120 horizontally and 1:30 vertically reproducing about five miles of the Red River in the vicinity of the proposed Lock and Dam is being used for the study.

318-09682-300-13

REHABILITATION OF MISSISSIPPI BASIN MODEL, INCLUDING VERIFICATION TO 1973 CONDITIONS, AND INITIAL TESTING RELATIVE TO PROJECT FLOOD

(*b*) Lower Mississippi Valley Division.
(*c*) J. V. Allen.
(*e*) Rehabilitate the portion of the Mississippi Basin Model from Hannibal to Baton Rouge in preparation for future testing and verify to 1973 stage-discharge relationships and to conduct initial tests of the Mississippi River and Tributaries Project Design Flood.
(*g*) The model has been rehabilitated from Hannibal to Baton Rouge with the Hannibal to Memphis portion of the model currently being verified to 1973 conditions. Project flood tests are being conducted initially in the Red River backwater area to assist the Vicksburg District in the design of levees. (This portion of model has been verified.)

318-09683-350-13

REND LAKE PROTOTYPE TESTING

(*b*) Lower Mississippi Valley Division.
(*c*) E. D. Hart.
(*e*) Determine intake, gate slot, and resistance losses, and the development of turbulent velocity distribution within a rectangular outlet conduit.
(*g*) Two WES hydraulic engineers, with assistance from the District, made piezometer pressure measurements and velocity probe transverses along the conduit plus downstream discharge measurements at the project. The tests were made with the west conduit flowing full with the gate full open and with the east conduit closed for access to the measuring points.
(*h*) Report in process.

318-09684-350-13

RIGOLETS CONTROL STRUCTURE

(*b*) New Orleans District; Lower Mississippi Valley Division.
(*c*) R. Charles Berger.
(*e*) Determine the adequacy of the design for the flow control structures in the hurricane surge protection barrier across the Rigolets at the original and alternate locations. The tests will be conducted on a fixed-bed model constructed to an undistorted scale of 1:100 with an area of about 22,000 sq. ft. The model will be equipped with the necessary pumps, pipes, and valves to establish steady-state flow regimes in either the flood or ebb direction with equipment required to measure water-surface elevations and velocities.
(*g*) Testing of three different control structure designs (Plans 1, 2, and 3) will be completed in April 1975.

318-09685-070-13

SEEPAGE MODEL STUDIES

(*b*) Lower Mississippi Valley Division.
(*c*) Y. S. Jeng.
(*e*) Develop experimental and numerical techniques to obtain solutions to some of the more complex seepage problems encountered within the Lower Mississippi Valley Division. A three-dimensional electrical analogy model will be used to solve underseepage problems and a viscous flow model will be used to solve transient groundwater flow problems. Numerical techniques will be developed for analysis of fluid flow through soils on the basis of the finite difference and finite element methods.
(*g*) The computer code is operational and a user manual has been prepared. Most of the work on the following items has been completed: (1) criteria to aid in selecting mesh size and time increment; (2) scheme to modify time increment automatically; (3) effects of the location of impervious boundary on the free surface in a bank; (4) improvement in accuracy by using 4-, 8-, and 12-node elements (partial conclusions); and (5) preparation of design charts for choosing stable slopes for banks with typical slope angles, rate of drawdown and permeabilities. Satisfactory agreement was obtained between the results from the finite difference scheme and the model experiments both for rising and falling river stages. The one-dimensional finite element formulation has shown satisfactory correlation with results from the viscous flow model. A two-dimensional finite element formulation has also shown satisfactory correlation with typical laboratory and field observations. Design curves from numerical methods are possible for certain common situations.

318-09686-300-13

LITTLE BLUE RIVER CHANNEL IMPROVEMENT MODEL STUDY

(*b*) Kansas City District.
(*c*) Maurice James, Analysis Branch.

(*e*) Develop design data for the resistance caused by (1) shear interface caused by addition of berms to low flow channels, (2) low flow channel crossing from side to side in the main channel, (3) resistance to bends, and (4) resistance caused by trees and other plantings. The model is constructed in a 5-foot wide by 96-foot long tilting flume. Tests will be conducted to develop normalized rating curves for each cross-section and to define energy losses as a function of channel geometry. Representative velocity determinations are being obtained for the various channel configurations.
(*g*) This investigation is in the final stages of analylsis. The study of the low flow channel with various berm widths has been completed. The crossover data is now in the model, and testing is continuing. Data obtained from the first phases of testing is being analyzed by WES, and several relationships have been obtained which will prove helpful in future design problems.

318-09687-470-13

NEWBURYPORT HARBOR MODEL STUDY

(*b*) New England Division.
(*c*) N. J. Brogdon, Jr.
(*e*) Investigate proposed plans and/or modifications to existing projects in an effort to determine their effects on channel shoaling in the harbor entrance, small boat navigation, erosion of Plum Island Point, existing salinity conditions, and water quality. A combination fixed-bed and movable-bed model has been constructed, which includes a portion of the Atlantic Ocean, Newburyport Harbor, and the Merrimack River to head of tide. Linear scales are 1:100 vertically and 1:300 horizontally. The model is equipped to reproduce tides, tidal currents, wave action, density currents, and freshwater inflows.

318-09688-310-13

FOURMILE RUN FLOOD CONTROL PROJECT, VIRGINIA

(*b*) Baltimore District.
(*e*) The model reproduced the proposed Fourmile Run earth channel in the upstream reaches of the project for approximately 5,000 feet. Model studies were conducted simulating the channel hydrograph.
(*h*) Report in process.

318-09689-350-13

TIOGA-HAMMOND LAKES, PENNSYLVANIA: COMBINED OUTLET WORKS AND CONNECTING CHANNEL

(*b*) Baltimore District, North Atlantic Division.
(*e*) Investigate the design of the Tioga outlet works and the design of the Hammond (connecting channel) outlet works presented in Design Memorandum No. 18, Outlet Works and Connecting Channel. To investigate the hydrodynamic behavior of the two-lake system. The model studies will determine the hydraulic pressures and flow characteristics for a wide range of conditions and will aid in verification and/or refinement of the Tioga stilling basin and outlet channel, Hammond plunge pool and weir, and the Hammond intake structure and outlet works. The hydrodynamic model will simulate the density structures expected in the two impoundments and will determine the effect of flow through the connecting channel on water quality for the impoundments and for reservoir releases.

318-09690-350-13

RAYSTOWN LAKE PROJECT, PENNSYLVANIA: PROTOTYPE TESTING

(*b*) Baltimore District.
(*e*) Investigate flow conditions over the spillway weir and chute and performance of the spillway flip bucket at lower end of the chute. Prototype testing will include measurements of (a) velocity profile and static pressure, (b) air entrainment, (c) photographs of the flip bucket trajectory and spillway watersurface profile, and (d) discharge.

318-09691-350-13

COWANESQUE LAKE, PENNSYLVANIA: SPILLWAY MODEL

(*b*) Baltimore District.
(*e*) Investigate flow conditions over the spillway. Testing included the establishment of flow profiles for spillway discharges up to and including the spillway design flood and approach flow patterns and velocities, development heights, convergence configuration, and approach design.
(*g*) Observations of the model indicated that the capacity of the spillway was less than the 224,000-cfs design capacity, due primarily to lateral flow approaching the spillway from the face of the embankment. The addition of an upstream left abutment training wall, excavation in the approach channel, and modified convergence has resulted in a design capable of passing the design storm with the reservoir at the desired elevation.

318-09692-430-13

JAMICA BAY HURRICANE SURGE STUDY

(*b*) New York District; North Atlantic Division.
(*c*) R. F. Athow, Jr.
(*e*) Develop a barrier plan that will prevent flooding within the bay and associated lowlands during periods of northeasterly winds or hurricanes, and to determine the effects of the plan on tides, velocities, salinities and dye concentrations within Jamaica Bay, and navigation, and to improve circulation and water quality in the bay by developing the required design and operating procedure for the tidal passages in the barrier and, if necessary, developing the design for training dikes and/or channel improvements. The comprehensive fixed-bed model of New York Harbor, with linear scale ratios of 1:1000 horizontally and 1:100 vertically, is being used for the physical model of Jamaica Bay study. This will be augmented by construction of an undistorted section of the selected barrier to solve erosion problems and operating techniques. A model developed as a separate study by Dr. Leendertse (Rand Corporation) is being used for the mathematical model.
(*g*) The detailed tide and current measurements in Rockaway Inlet requested by Dr. Leendertse for establishing boundary conditions for the mathematical model were obtained and furnished to him. Base tests to establish existing conditions of tidal heights, current velocities, salinities, and dye dispersion patterns were completed, and repetitive tests with the planned structure in Rockaway Inlet installed were completed. Data analysis is in progress.

318-09693-350-13

MODEL STUDY OF SOUTH ELLENVILLE FLOOD CONTROL PROJECT

(*b*) New York District.
(*c*) J. L. Grace, Jr.
(*e*) Investigate flow conditions in the high velocity chute and stilling basin of the project. Of particular interest were the disturbance effect of large boulders in the chute and the adequacy of the alignment and superelevation of the sinuous high velocity channel. Erosion characteristics below the stilling basin also were determined. Tests were conducted on a 1:20-scale model that reproduced the high velocity chute and stilling basin and sufficient areas of the approach and exit channels to investigate flow conditions throughout the project.
(*f*) Completed.
(*h*) **South Ellenville Flood Control Project, Rondout Creek Basin, New York,** *TR H-74-2*, Apr. 1974.

318-09694-330-13

MATHEMATICAL MODEL STUDY OF A FLOW CONTROL PLAN FOR THE CHESAPEAKE AND DELAWARE CANAL

(*b*) Philadelphia District, North Atlantic Division.
(*c*) Billy H. Johnson.
(*e*) The Mathematical Hydraulics Division at WES proposed to the Philadelphia District a Mathematical Model Study

with the purpose of arriving at a suitable solution for reducing the net flow in the C and D Canal to values comparable to those encountered with a 27 ft by 250 ft channel. The most logical flow control scheme was a navigation lock and dam in the canal with a smaller bypass canal. A mathematical model study was made to determine the bypass and lengths and cross-sections that would be required to reduce the net flow or maximum velocity to pre-project conditions.

(*f*) Completed.

318-09695-350-13

BELTZVILLE DAM – PROTOTYPE TESTS

(*e*) Obtain information concerning the hydraulic performance and optimum operating condition of the multi-level water quality intakes and the flood control outlet for which no similar prototype data are available, and to obtain prototype data to correlate with model data and use in developing improved hydraulic design criteria. Measurements included conduit wall pressure fluctuations, conduit discharge, air demand, jet impact pressure, flow pressure fluctuations below water quality control gate, and elbow pressures for discharge calibration and model comparison.

(*g*) The tests were conducted in early May 1973. The data are currently being reduced and analyzed prior to preparation of a final report.

318-09696-330-13

SHOALING STUDIES OF TWENTY-FIVE FOOT CHANNEL IN JAMES RIVER

(*b*) Norfolk District, North Atlantic Division.

(*c*) R. A. Boland, Jr., Estuaries Branch.

(*e*) The plan is to investigate dikes, spoil disposal areas, sediment traps, and channel realignments in an effort to reduce shoaling in the existing 25-ft channel. Tests are conducted in the existing fixed-bed James River model (scales 1:100 vertically and 1:1000 horizontally).

(*g*) Insofar as the return of dredge spoil to the navigation channel is concerned, the test results indicate that the only problem areas are the downstream 4000 ft of the disposal area for Tribell Shoal and the downstream 9000 ft of the disposal area for Goose Hill Flats Shoal. The test results also show that use of alternate areas on the opposite side of the channel would essentially eliminate the return of spoil to the channel for both of the above areas; however, the biological effects of relocating the disposal areas will have to be considered before a change from the present areas can be made. The test results also show that the proposed spoil disposal area just downstream from Herring Creek, which would be used during dredging operations in the central portion of Jordan Point to Windmill Point Shoal, would probably be undersirable because of the indicated large movement of spoil into Herring Creek.

318-09697-330-13

OPTIMIZATION OF LOCK UTILIZATION

(*b*) Louisville District.

(*c*) L. L. Daggett.

(*e*) Develop a real time computerized lock control assistance system whereby a lock operator can easily determine the best order in which to schedule approaching tows for lockage, so as to optimize lock operations. The study included defining the objective functions to be optimized, e.g., minimizing delay time per tow, maximizing total tonnage, maximizing total tows, or maximizing total barges; identifying and quantifying easily measurable variables that significantly influence tow lockage times, and developing a simulation and optimization program.

(*g*) The development of the optimization program for determining the best order in which to lock waiting tows is complete. Representative queues have been used to demonstrate the benefits of using the optimizing functions.

(*h*) **Analysis of Tow Entry, Locking, and Exit Times, Lock and Dam 51, Ohio River,** *Misc. Paper H-74-4*, Mar. 1974.

Use of Tow Sequencing Procedures to Increase the Capacity of Existing Lock Facilities, *Technical Rept. H-74-5*, June 1974.

318-09698-350-13

MODEL STUDY OF OUTLET WORKS, TAYLORSVILLE LAKE

(*b*) Ohio River Division, Louisville.

(*c*) J. P. Bohan.

(*e*) Evaluate the operation and performance of the Taylorsville Lake outlet works. The ability of the outlet works to pass the desired flows through the selective withdrawal and flood control systems without creating adverse flow conditions and damaging low pressures will be determined. The model will also serve as a tool for developing and testing any revisions needed to enhance performance. A 1:25-scale model of the intake structure, flood control conduit, and stilling basin is being used for the study. A 200-ft length of exit channel and a reservoir approach area 300 ft wide by 400 ft long are reproduced. The intake structure and conduit are made of transparent plastic to observe flow conditions, and piezometers are placed throughout these structures to measure pressures.

(*g*) Testing has been completed, and preparation of the final report is in progress. The study concluded that the proposed outlet works will release the desired flood control and water quality discharges without experiencing detrimental pressure conditions if certain operating conditions are avoided. A stilling basin (type 8) was developed and recommended over the original design basin. The type 8 basin provided adequate flow distribution and sufficient energy dissipation for the full range of discharges.

318-09699-300-13

MODIFICATION AND APPLICATION OF UNSTEADY FLOW MODEL – OHIO, CUMBERLAND, TENNESSEE AND MISSISSIPPI RIVER SYSTEM

(*b*) Ohio River Division.

(*c*) B. H. Johnson.

(*e*) Provide ORD with a mathematical model which will enable them to accurately predict stages and discharges at Cairo, Ill., as well as at other points along the river system being modeled. A mathematical model (SOCHMJ) was developed for the computation of unsteady flows in a system composed of an unlimited number of junctions. The model was then calibrated for the system consisting of the lower Ohio, Cumberland, Tennessee, and Mississippi Rivers using geometric data from the Mississippi Basin Model (MBM). In this effort SOCHMJ was extended up the Ohio only to Golconda, Ill. An additional effort has been initiated to extend the model to Louisville, Ky. In order to perform this extension, the model must be modified to include the capability of forecasting flow and stages with the high-lift navigation locks and dams under construction included in the system. In addition, the Salt, Green, and Wabash Rivers will be included as dynamic branches of the system.

(*g*) All work on the original project has been completed. Work on the extension of the model is progressing. The model has been modified to allow two time step sizes to be employed. This allows one to model a system containing both large and small spatial step sizes at much lower requirements in computation time than when employing a single time step for such a system. Work on the development of an algorithm to handle the high-life navigation locks and dams has been completed and will be checked through sample computer runs.

(*h*) **Unsteady Flow Computations on the Ohio-Cumberland-Tennessee-Mississippi River System,** *Tech. Rept. H-74-8*, Sept. 1974.

318-09700-860-13

WATER QUALITY STUDY OF BAY SPRINGS RESERVOIR

(*b*) Ohio River Division.

(*c*) J. P. Bohan.

(*e*) Investigate and determine the effect of lock operation on flow patterns and water quality within and downstream of Bay Springs Lake. Two physical models will be used to investigate the selective withdrawal characteristics of the Bay Springs lock intakes and the reservoir hydrodynamics as influenced by unsteady state operation of the lock. The results of the physical models will be incorporated into a mathematical model which will be used to simulate the reservoirs' thermal and dissolved oxygen regimes.
(*g*) The vertical extent of withdrawal from Bay Springs is controlled by the elevated topography just upstream of the lock intakes. Surface withdrawal occurs when the thermocline is below the elevation of this local topography. When the thermocline is above the local topography at the lock, withdrawal occurs down to a lower limit. The inflow from the canal to Bay Springs Lake does not mix with hypolimnion water. Even under extreme flow conditions no mixing of inflow and hypolimnion occurs.

318-09701-330-13

BAY SPRINGS CANAL SURGE STUDY

(*b*) Ohio River Division, Nashville.
(*c*) J. P. Bohan.
(*e*) Determine the effect of the releases from Bay Springs Lock on Navigation in the relatively small canal below the lock. A 1:80-scale model of 4000 ft of canal below the Bay Springs will be constructed. The lock release hydrograph will be simulated using electrically automatic equipment. Water level detectors will be used to plot surge heights. Strain gages will be used to instrument a model tow while moored at various locations in the canal.

318-09702-330-13

MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR BAY SPRINGS LOCK, TENN-TOMBIGBEE WATERWAY

(*b*) Ohio River Division.
(*c*) J. H. Ables, Jr.
(*e*) Develop a longitudinal floor culvert filling and emptying system for a 110-ft by 600-ft lock with a maximum head of about 84 feet. The model will reproduce the entire filling and emptying system and short portions of the approaches at a scale of 1:25. Usual instrumentation will be provided.

318-09703-350-13

CHUTE DISSIPATOR MODEL STUDY IN DIVIDE CUT, TENN-TOM WATERWAY

(*b*) Ohio River Division.
(*c*) J. H. Ables, Jr.
(*e*) The four major drainage structures or baffled chutes will be designed to accommodate 50-year frequency discharges, and the height of sidewalls will be increased in an attempt to contain the 100-year flows. The side slopes of the Divide Cut will also be established. Because the proposed slopes of the chute dissipator have not been tested or reported and the magnitude of unit discharge is at the upper end of available data for other slopes, a model study was recommended. The study of the chute energy dissipators is being conducted in a 1:25-scale model including approximately 300 ft of the approach channel, the transition to the 168-ft-wide chute, the energy dissipator and stilling pond, and a section of the canal approximately 600 by 275 feet.
(*g*) The baffles on the 168-ft-wide chute were removed and an attempt was made to develop a more economical dissipator for the four major drainage structures. The performance of seven stilling basin schemes with aprons ranging from 13 to 25 ft long at elevation 396 was observed. The grade of the stilling pool was raised to elevation 396 which is coincidental with the canal invert. Various combinations of chute blocks, baffle blocks, and stills were investigated. A 15-ft-long apron equipped with 2-ft-high by 2-ft-wide baffle blocks, spaced 2 ft apart and positioned 7.5 ft from the toe of the apron, and terminated with a 2-ft-high sloping sill was found to be the best basin of this type; however, velocities entering the canal were too large for navigation past the structure. The chute width, therefore, could not be reduced, and it was necessary to restore the baffles to reduce significantly velocities entering the canal for navigation purposes.

318-09704-350-13

SPLITTER WALL DISSIPATOR MODEL STUDY IN DIVIDE CUT, TENN-TOM WATERWAY

(*b*) Ohio River Division.
(*c*) J. H. Ables, Jr.
(*e*) Due to the unusual nature of the splitter wall basin and the problems that may be encountered with the hydraulic jump in the closed conduit upstream from this basin, a model study was recommended. The dissipator located in the floor of the canal may be a potential source of trouble during maintenance dredging. The study of the splitter wall is being conducted in a 1:10-scale model that reproduces three exit channels downstream from the Type VI basins, a portion of the connecting channel, the entrance transition, the chute, the splitter wall basin, and a portion of the canal approximately 200 by 140 feet. The hydraulic characteristics of the structures are not readily determined by mathematical analyses and will be determined by model tests.
(*g*) A satisfactory entrance transition to the chute could not be developed so a drop structure was developed to bring flow into the chute without significantly increasing headwater depth. The closed conduit at the downstream end of the chute adjacent to the splitter wall dissipator was removed in order to pass the full range of discharges with all tailwater conditions. Refinements of the upstream drop structure into the chute and a basin type energy dissipator in the canal are being investigated.

318-09705-350-13

MODEL STUDY OF BURNSVILLE SPILLWAY

(*c*) J. P. Bohan.
(*e*) Investigate flow conditions in the approach and exit channel, develop an adequate stilling basin, and determine the extent and size of riprap required for protection in the exit area. The tests were conducted in a 1:40-scale model that reproduced the entire spillway, approach area (1000-ft-long and 1100-ft-wide), and exit area (2600-ft-long and 1000-ft-wide). Observations of flow conditions with various sluice and spillway releases were made and stone protection in the exit area was reproduced and tested under different flow conditions.
(*g*) Tests completed. Report in progress.

318-09706-430-13

MASONBORO INLET MODEL STUDY

(*b*) Wilmington District.
(*c*) Wave Dynamics Division.
(*e*) Tests were conducted in the existing fixed-bed hydraulic model of Masonboro Inlet to define the effects of the proposed south jetty plans on current patterns, current magnitudes, tidal heights, and sediment motion.
(*h*) Report in preparation.

318-09707-430-13

OREGON INLET MODEL

(*b*) Wilmington District.
(*c*) Wave Dynamics Division.
(*e*) Determine flow control characteristics of the proposed jetty system. This includes evaluating navigability of the entrance, stability of the channel, bay water level fluctuations and sediment movement. Additionally, structural tests will be undertaken for the purpose of obtaining design wave-damage relationships necessary for optimum structural design of the jetty structures.
A fixed-bed model of the inlet will be constructed. After collection of prototype data and verification of the model,

the plan will be installed and evaluated by measuring current directions and magnitudes, tidal evaluations, surface current patterns, and sediment tracer movement. Structural tests for the jetty trunk and head sections will be performed in the two-dimensional and three-dimensional wave tanks, respectively.

(*g*) Field data collection for model construction, calibration, and verification will continue through June 1975. Primary data collection is the responsibility of the National Ocean Survey which is conducting the collection program for SAW on a reimbursable basis.

318-09708-430-13

CAROLINA BEACH INLET, NORTH CAROLINA – 80870 NUMERICAL MODEL STUDIES OF INLET AND ESTUARINE SYSTEM

(*b*) Wilmington District.

(*c*) Mathematical Hydraulics Division.

(*e*) The Wilmington District (SAW) is conducting a general investigation of the feasibility of providing improvements for navigation of Carolina Beach Inlet, N. C., taking into consideration erosion along adjacent shores and estuarine water quality. The planning effort includes the development and operation of a numerical flow and salinity transport model of Carolina Beach Inlet and its associated estuary. The output of the subject model is to be utilized in the plan formulation process which will involve consideration of numerous plan alternatives each of which would, if implemented, result in changes to the hydrodynamic and salinity regimen within the study area. Accordingly, the primary data to be generated by the model computation are vertical tides, currents and discharges, and salinity concentrations.
An existing numerical model capable of treating unsteady flow problems in channel networks will be adapted to the study. Modifications required include special treatment of boundary conditions at the open boundaries and the development of a method to handle flooding marshlands. Following these model modifications the different possible navigation improvements will be evaluated through appropriate test computations.

(*g*) Field data collection for the purpose of model calibration and verification was completed November 1974. Field data is now being reduced. Detailed planning with respect to model adaptation is also in progress.

318-09709-300-13

MAYPORT-MILL COVE MODEL STUDY

(*b*) Jacksonville District.

(*c*) N. J. Brogdon, Jr.

(*e*) Investigate the existing shoaling problem in the entrance, Mayport Basin and Mill Cove, and the pollution problems of Mill Cove and Jacksonville Harbor. Several plans will be investigated in an effort to alleviate the above problems. A fixed-bed model will be constructed which will include all of St. Johns River downstream from Hibernia Point and tidal portion of adjacent rivers and marshes, all of Mayport Basin and Mill Cove, adjacent portions of the intercoastal waterways system, and a suitable area 1:500 horizontally and 1:50 vertically. The model will be equipped to reproduce tides, tidal currents, density currents, and freshwater inflow.

(*g*) Construction in progress.

318-09710-350-13

MODEL STUDY OF PORTUGUES AND BUCANA CHANNEL IMPROVEMENT PROJECT

(*b*) Jacksonville District.

(*c*) N. R. Oswalt.

(*e*) Verify the adequacy of and develop desirable modifications to the transitions from the trapezoidal to rectangular channels, the stilling basins and transitions at the downstream ends of the concrete channels and the drop structures. Two 1:30-scale models will be constructed and operated concurrently for study of the problem areas. One model will reproduce the Bucana channel between stations 131+20 and 164+00 and will be used to study the transitions and stilling basins including riprap stability downstream from the basins. The other model will reproduce about 1300 feet of the 150-ft-wide Bucana channel and will be used to study the drop structures.

318-09711-470-13

GEORGETOWN HARBOR MODEL STUDY

(*b*) Charleston District.

(*c*) Mr. R. A. Boland, Jr., Estuaries Branch.

(*e*) Investigate the excessive shoaling condition and evaluate various plans to eliminate or greatly mitigate the shoaling rate and associated disposal area problem. Consideration will be given to diverting the large freshwater inflow to Winyah Bay from the Black, Pee Dee, and Waccamaw Rivers.
The effects of channel modifications, being considered in the district's navigation study, on tides, currents, salinities, shoaling and circulation patterns will be determined. The effects on tides, currents, salinities, shoaling distributions, circulation patterns and flushing will be determined by direct comparison of physical model test results with and without proposed changes in the system.

(*g*) Model construction has been completed. Model verification of tide velocities and stages complete. Verification of salinities expected to be complete by end of February 1975.

318-09712-470-13

CHARLESTON HARBOR MODEL STUDY

(*b*) Charleston District.

(*c*) W. H. Bobb, Estuaries Branch.

(*e*) The proposed model tests were to determine the effects of of Cooper River navigation channel deepening (40 and 45 feet) on tides, currents, and salinities; the effects of extending navigation upstream to Bushy Park including evaluating the possibility of contamination of the industrial water supply; the effects of the State Ports Authority's Wando River Terminal, container ship facility, to be constructed in the near future; the most desirable channel alignment of the State Ports Authority future container facility to be located adjacent to Clouter Creek on the east side of the Cooper River; the effects of the future Clouter Creek Development on shoaling in the adjacent reach of Cooper River; and the effects of extending the jetties (particularly the north jetty) inland to shore in an effort to reduce inner harbor shoaling.
Comparative tests involving measurements of tides, currents, salinities, and dye dispersion for existing and proposed conditions will be conducted in the fixed-bed model which reproduces that portion of the Atlantic Ocean adjacent to the harbor entrance, all of Charleston Harbor, and the tidal reaches of the Ashley, Cooper and Wando Rivers (scales of 1:2000 horizontally and 1:00 vertically).

(*g*) Testing has been completed for existing base tests; Wando channel (35 ft) to proposed State Ports Authority's terminal; extension of Wando channel upstream to Highway 41 bridge; deepening existing commercial navigation channel to 40 ft; and extending 40 ft commercial navigation channel to Bushy Park (mi. 33.4).

318-09713-430-13

MODEL STUDY OF MURRELLS INLET, SOUTH CAROLINA

(*b*) Charleston District.

(*c*) Mr. Wade Mallard, Hydraulics Laboratory.

(*e*) Evaluate the effectiveness of a proposed jetty system for navigational improvement of Murrells Inlet and feasible modifications to the plan for establishing a stable naviga-

tion channel through the inlet. Fixed bed model tests will be conducted to define the effectiveness of various jetty configurations in maintaining a stable channel.
(*g*) The model is under construction, and verification is expected to be initiated by the end of January 1975.

318-09714-430-13

MODEL STUDY OF LITTLE RIVER INLET, NORTH CAROLINA AND SOUTH CAROLINA

(*b*) Charleston District.
(*c*) Mr. William Seaberg, Hydraulics Laboratory.
(*e*) Evaluate the effectiveness of a proposed jetty system for navigational improvement of Little River Inlet and feasible modifications to plan for establishing a stable navigation channel through the inlet. Fixed bed model tests will be conducted to define the effectiveness of various jetty configurations in maintaining a stable channel.
(*g*) The model is under construction. Verification is expected to be initiated in March 1975.

318-09715-860-13

RICHARD B. RUSSELL LAKE WATER QUALITY INVESTIGATION

(*b*) Savannah District.
(*c*) D. Fontane; J. Bohan.
(*e*) Describe the thermal and dissolved oxygen regimes above, within and below the proposed Trotters Shoals impoundment on the Savannah River. Physical models were used to investigate the dynamic effects of power generation and pumpback operations on the thermal stratification in Trotters Shoals, Clark Hill, and Hartwell impoundments. The results were used to improve a mathematical simulation technique for analysis of the temperature and dissolved oxygen regimes in the study region of the Savannah River.
(*f*) Completed.
(*g*) Physical model tests to check the selective withdrawal through the inclined power penstocks indicate that the selective withdrawal prediction technique must be modified to allow prediction of the observed flow distributions. The physical models of the Trotters Shoals and Clark Hill reservoirs have been used to develop guidance for modifying the mathematical model to handle the extremely dynamic operation of the three-reservoir system with both conventional and pumped-storage power generation at Trotters Shoals. The math model has been run with these modifications and the results indicate that the stratification in the reservoirs will not be destroyed by the dynamic operation of the powerhouses. The results further indicate that the temperature objectives for a trout fishery will be maintained in the entire study reach of the river and that the dissolved oxygen objectives will not be met without some type of oxygen injection system.
(*h*) Final report submitted December 1974.

318-09716-860-13

FALLS LAKE WATER QUALITY STUDY

(*b*) Savannah District.
(*c*) B. Loftis; D. Fontane.
(*e*) Describe the thermal and dissolved oxygen regimes of the proposed Falls Lake Project and evaluate the adequacy of the proposed multilevel intake structure in satisfying downstream temperatures and dissolved oxygen objectives. The approach to the study was to modify a mathematical model that was used to simulate, for selected study years, the thermal and dissolved oxygen regimes within the proposed Falls Lake.
(*g*) The simulation results indicate that Falls Lake can generally meet downstream temperature requirements, particularly if low level outlets are included in the structure. The dissolved oxygen content within the impoundment will generally be low because of the high BOD loading being introduced upstream. Piggyback gates in the flood-control service gates will be recommended in the report in order to increase the dissolved oxygen of the low level releases.
(*h*) Report in preparation.

318-09717-300-13

MODEL STUDY OF SUCK BEND, CHATTAHOOCHEE RIVER

(*b*) Mobile District.
(*c*) J. E. Glover.
(*e*) Develop plans to reduce or eliminate shoaling in Suck Bend, Chattahoochee River. A movable-bed hydraulic model reproducing a section of the river from navigation mile 73.0 to 74.4 to an undistorted scale of 1:72 was used to study the problem.
(*g*) A plan which will reduce shoaling and provide a satisfactory navigation channel through the reach has been developed. Model testing has been completed and test data are being assembled and analyzed.

318-09718-350-13

MODEL STUDY OF ALICEVILLE SPILLWAY, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) N. R. Oswalt.
(*e*) Develop an energy dissipator and riprap plan thatwould provide adequate protection for normal and emergency operating conditions. A 1:36-scale hydraulic model reproducing both controlled and uncontrolled spillways with 500 ft of upstream and 1800 ft of downstream topography was used to evaluate performance of propsoed stilling basins and riprap protection.
(*f*) Completed.
(*g*) A stilling basin apron elevation of 87 is adequate for single gate operation. Three different riprap sizes ranging from 1600 to 300 lb (D_{50}) are adequate for downstream protection. A 130-ft riprap dike near the lower lock approach was installed to eliminate eddies in the approach area.
(*h*) *Report TR H-74-10*, Oct. 1974.

318-09719-330-13

MODEL STUDY OF ALICEVILLE LOCK AND DAM, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) L. J. Shows.
(*e*) Study navigation conditions in the lock approach and current conditions in the diversion canal during construction of the lock and dam. The model is of the fixed-bed type constructed to an undistorted scale of 1:100, reproducing about three miles of the Tombigbee River Channel near Pickensville, Alabama, Lock and Dam diversion canal and adjacent overband areas.
(*g*) All scheduled testing has been completed. Analysis of the results of completed tests has been undertaken. Satisfactory navigation conditions can be developed in both the upstream and downstream lock approaches at the proposed site.

318-09720-350-13

MODEL STUDY OF COLUMBUS SPILLWAY, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) Glenn A. Pickering.
(*e*) Assist in developing an energy dissipator and riprap plan that would provide adequate protection for normal and emergency operating conditions. A 1:36-scale hydraulic model reproducing a controlled spillway with 500 ft of upstream and 1800 ft of downstream topography was used to evaluate performance of the proposed stilling basin and riprap protection.
(*f*) Completed.
(*g*) A stilling basin apron elevation of 112 is adequate for full open-single gate operation. Three different riprap sizes ranging from 1600 to 300 lb ((D_{50}) are adequate for downstream protection.
(*h*) *Rept. TR H-74-13*, Nov. 1974.

318-09721-330-13

MODEL STUDY OF COLUMBUS LOCK AND DAM, TENN-TOM WATERWAY

(b) Mobile District.
(c) L. J. Shows.
(e) Determine flow conditions and their effects on navigation and develop modifications in the plan that might be considered desirable for the complex arrangement of the various channels and diversions. A fixed-bed model was constructed to an undistorted scale of 1:120. The model reproduces the Tombigbee River Channel from about 8,000 ft downstream to about 18,000 ft upstream of the dam, about 10,000 ft of the lower Tibee River Channel, pertinent adjacent overbank areas, and the lock and dam and navigation canals.
(g) All scheduled testing has been completed. Analysis of the results of completed tests has been undertaken. Satisfactory navigation conditions can be developed in both the upstream and downstream lock approaches at the proposed site.

318-09722-330-13

MODEL STUDY OF ABERDEEN LOCK AND DAM, TENN-TOM WATERWAY

(b) Mobile District.
(c) L. J. Shows.
(e) Develop plans which will provide good navigation conditions in the lock approaches and minimize the adverse effects of the left overbank flow on tows moving through the navigation channel during high stages. The model is of the fixed-bed type, constructed to an undistorted scale ratio of 1:120, and reproduces a short reach of the Tombigbee River upstream and downstream of the dam, the approach channel to the lock, the lock and dam structure, and the adjacent overbank areas.
(g) Operation of the model for tests of the Base Plan has been completed. Operation of the model for the development of modifications required to improve navigation in the lock approaches has been undertaken.

318-09723-330-13

MODEL STUDY OF GAINESVILLE LOCK AND DAM, TENN-TOM WATERWAY

(b) Mobile District.
(c) L. J. Shows.
(e) Investigate navigation conditions near the upstream entrance to the proposed lock canal and flow conditions in the approach to the spillway, and develop modifications required to eliminate any undesirable conditions. The model is of the fixed-bed type constructed to an undistorted scale of 1:100. The model reproduces about 2-1/2 miles of the Tombigbee River between river miles 283 and 286, about 1-1/2 miles northeast of Gainesville, Alabama, adjacent overbank areas, gated spillway, upper reach of the lock approach canal, fills, and overflow sections.
(g) Satisfacory navigation can be developed at the entrance to the lock approach canal and in the waterway upstream of the canal. The development of basic plans required for satisfactory navigation for one- and two-way traffic has been completed. All scheduled testing has been completed. Analysis of the results of completed tests has been undertaken.

318-09724-470-13

THEODORE SHIP CHANNEL STUDY IN MOBILE BAY MODEL

(b) Mobile District.
(c) R. A. Boland, Jr.
(e) Define the effects of the proposed Theodore Ship Channel (40 by 400 ft) and disposal islands on tides, currents, salinities, circulation patterns, and flushing in Mobile Bay. Tests were conducted in a fixed-bed model constructed to linear scales of 1:1000 horizontally and 1:100 vertically. The model reproduces about 268 square miles at the Gulf of Mexico from Pine Beach on the east to about the west end of Dauphin Island, and extends to about the 70-ft contour of depth in the Gulf; all of Mobile and Bon Secour Bays; a portion of Mississippi Sound; and the Mobile and Tensaw Rivers and adjacent marshes to the junction of the two rivers at Mt. Vernon, some 40 miles upstream from Mobile. The total area covered by the model is about 1073 square miles. The effects on tides, currents, salinities, circulation patterns, and flushing were determined by direct comparison of model test results with and without the proposed Theodore Ship Channel and various spoil island configurations.
(h) Report in progress.

318-09725-350-13

WALNUT CREEK PROJECT, BROADWAY CONDUIT MODEL STUDY

(b) Sacramento District.
(c) Glen Pickering.
(e) The hydraulic capacity of the existing Broadway Conduit at the confluence of Walnut, San Ramon, and Las Trampas Creeks, Walnut Creek, California, is to be determined. Should the conduit be inadequate to pass design flows, appropriate modifications to the structure will be investigated. As the capacity of the structure cannot be reliably calculated, a hydraulic model study will be employed.
(g) Initiation of model construction is imminent.

318-09726-400-13

HYDRAULIC MODEL STUDIES OF SAN FRANCISCO BAY AND SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA

(b) San Francisco District.
(c) Mr. Marshall A. Blank.
(e) The purpose of the model studies is threefold: (1) to support the San Francisco Bay and Sacramento-San Joaquin Delta Water Quality and Waste Disposal Investigation (this relates to model studies of interdistrict and interagency proposed plans that can influence water quality in the Bay and/or Delta), (2) to provide a means of evaluating other plans and operating procedures in the Bay-Delta Estuary, and (3) to provide a laboratory for research and development for studies and proposals of academic and regional interests. One plan is to prepare a velocity grid of the San Francisco Bay system which will indicate by arrows on a series of charts the surface current at two-hour intervals throughout the tidal cycle. This information will be of regional interest to the Coast Guard (oil spill planning), yachtsmen, and other local users of the San Francisco Bay Waters.
The method of evaluation consists of measurement and observation, including photographic methods, of tides, currents, salinity, sedimentation, and dispersion patterns under existing conditions of development and determination of changes in these items for various projects, proposals or concepts.
Base and Plan tests were conducted during the report period for various operating conditions for the J. F. Baldwin and Stockton ship channels project and for the proposed Peripheral Canal. Methods of operation and measurements were improved to achieve dependable repeatability of tests. Devices were added and improved to simulate both quantity and salinity of agricultural drainage from the islands in the Delta to the rivers and sloughs. The salinity results for both base and plan conditions have been put into a computer program which plots the input data and computes and plots the average of surface and bottom salinity. Model tests combining both the Peripheral Canal and the J. F. Baldwin and Stockton Channels projects have been completed. One objective was to determine the freshwater releases required to restore salinity to the base conditions.

(*h*) **Model Verification and Results of Sensitivity Tests,** *Tech. Memo. No. 1*, in preparation.

318-09727-330-13

MODEL STUDY McCLELLAN-KERR NAVIGATION POOL 13

(*b*) Tulsa District.
(*c*) J. E. Glover, Waterways Branch.
(*e*) Establish a shoal free channel between navigation mile 323.0 and 308.4 on the McClellan-Kerr Navigation Channel. A movable bed hydraulic model will reproduce this reach with a 1:120 horizontal scale and a 1:80 vertical scale. Model will be constructed in two parts with the upper part reproducing the reach between navigation mile 323.0 and 313. The lower model will reproduce the reach between navigation mile 314 and 308.4. Operation of the model will establish a shoal free channel by means of a system of channel rectification structure through the subject reach.
(*g*) The upper model has been constructed and initial operation for model adjustment began in February 1975.

U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS, CRYOGENICS DIVISION, Boulder, Colo. 80302. Richard H. Kropschot, Division Chief.

319-07003-230-50

CAVITATION SIMILARITY STUDIES

(*b*) National Aeronautics and Space Administration, Lewis Research Center.
(*c*) Mr. Jesse Hord, Mechanical Engineer.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Extend the capability to design and predict the performance of liquid pumps and other liquid-handling components. The experimental program requires testing of five hydrodynamic bodies in liquid hydrogen and liquid nitrogen; desinent, incipient, and developed cavitation data are acquired. The data are then analyzed and correlation techniques are developed to account for scale size, geometry, fluid, fluid velocity, fluid temperature, etc.
(*f*) Completed project.
(*g*) Experiments are completed. Data analysis, correlation, and extensions of cavitation-performance predictive techniques are also completed.
(*h*) **Cavitation in Liquid Cryogens, Volume II: Hydrofoil,** *NASA Rept. CR-2156*, Jan. 1973.
Cavitation in Liquid Cryogens, Volume III: Ogives, *NASA Rept. CR-2242*, May 1973.
Cavitation in Liquid Cryogens, Volume IV: Combined Correlations for Venturi, Hydrofoil, Ogives and Pumps, *NASA Rept. CR-2448*, Oct. 1974.

319-07005-110-00

CRYOGENIC FLOWMETERING

(*b*) Joint NBS-Compressed Gas Association Program.
(*c*) Mr. J. A. Brennan, Mechanical Engineer.
(*d*) Experimental; applied research.
(*e*) Determine performance of existing classical flow measurement devices under controlled cryogenic conditions; establish methodology for the use of these devices in cryogenic service; investigate new flow measurement methods.
(*g*) The facility is presently operational and is being used to evaluate measurement devices such as turbine, momentum, vortex shedding, and orifice meters.
(*h*) **An Evaluation of Several Cryogenic Turbine Flowmeters,** J. A. Brennan, R. W. Stokes, D. B. Mann, C. H. Kneebone, *NBS Tech. Note 624*, Oct. 1972.
An Evaluation of Selected Angular Momentum, Vortex Shedding and Orifice Cryogenic Flowmeters, J. A. Brennan, R. W. Stokes, C. H. Kneebone, D. B. Mann, *NBS Tech. Note 650*, Mar. 1974.
NBS-CGA Cryogenic Flow Measurement Program, J. A. Brennan, R. W. Stokes, C. H. Kneebone, D. B. Mann, *ISA Preprint 74-612*, Oct. 1974.

U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS, MECHANICS DIVISION, AERODYNAMICS SECTION, Washington, D. C. 20234. P. S. Klebanoff, Section Chief.

321-09730-700-34

AERODYNAMIC MEASUREMENTS

(*b*) With support by Federal Highway Administration and Bureau of Mines.
(*d*) Experimental and analytical; basic and applied research.
(*e*) To maintain, improve and develop methods, instruments and facilities for aerodynamic measurements, and to provide the extended calibration services for airflow measurements that are required. Current objectives are to develop capabilities for very low velocity measurements, and capabilities for measuring and characterizing the dynamic response of wind-speed measuring instruments. Specific areas of investigation are 1) the lag characteristics of meteorological anemometers and data important to understanding and characterizing their dynamic response (an unsteady flow facility for this study, which will also provide for a calibration capability in this area of flow measurement has been developed); 2) for the development of a facility for low-speed airflow employing laser velocimetery to provide for the calibration of low-speed anemometers.
(*g*) An investigation of the static and dynamic response of the Gill helicoidal anemometer has been completed. An operator's room has been constructed at the NBS Unsteady Flow Facility to protect personnel from the high noise level and the physiological effects of low frequency pressure fluctuations inherent in the operation of the facility. A gust and lull mechanism has been installed, and this mode of operation of the facility is presently being evaluated.
The interfacing of the laser velocimeter output electronics with a programmable calculator for data acquisition was completed and is in satisfactory operation. A new optics system for the laser velocimeter was designed and constructed which permits operation in either a backscatter or forward mode. Also, it provides for improved accuracy at the very low velocities. The laser velocimeter has been made operational down to 60 fpm. An analysis was made for further optimization of the system which revealed the desirability of several changes in the processing electronics. The necessary equipment for these changes has been ordered and delivered, and will be incorporated into the system after the construction of a three-dimensional traversing mechanism for the laser velocimeter is completed.
It is planned to develop a calibration capability at low velocities, and to initiate a state-of-the-art investigation of low-velocity anemometers. In the area of unsteady flows, it is planned to develop a calibration capability for the dynamic response of anemometers, and to conduct an investigation of the nonlinear spectral characteristics of the Gill helicoid anemometer.
(*h*) **The Dynamic Response of Helicoid Anemometers,** J. M. McMichael, P. S. Klebanoff, *NBSIR 75-772*, Nov. 1975.

321-09731-020-52

STRUCTURE OF TURBULENCE

(*b*) With support from ERDA.
(*c*) P. S. Klebanoff, NBS, and F. N. Frenkiel, NSRDC, Carderock, Md.
(*d*) Experimental, and analytical, basic research.

(*e*) To develop and devise measurement techniques incorporating analog and digital methods for the measurement of the statistical properties of turbulence, and to provide significantly new data which will extend our knowledge of turbulent processes. The microstructure of turbulence will be investigated using hot-wire instrumentation and high-speed computing methods. Analog recordings of turbulent data are made on multi-channel magnetic tape for a turbulent field established in the NBS wind tunnel. The analog data is digitized and analyzed at NSRDC. Both isotropic and anisotropic turbulent fields will be studied with special emphasis being given to the flow downstream of a turbulence producing grid and in a turbulent boundary layer. However, apart from the forementioned investigation, which is carried out in collaboration with NSRDC, there is, in addition, an investigation of the relatively unexplored turbulence structure of low Reynolds number turbulent boundary layers which will be studied using laser velocimetry and hot-wire anemometry.

(*g*) Attention was given to the analysis and reliability of the simultaneous measurements of the three components of turbulent velocity fluctuations. At this stage, the data for the three individual orthogonal velocity components, and their derivatives obtained from the specially designed three-component sensor, is satisfactory. This conclusion involved extensive comparison of the higher-order moments obtained from the three-component sensor with that obtained from the more conventional methods. Some difficulty has been encountered in the measurements of cross correlation. Analysis of the effect of free-streem turbulence level on the small-scale turbulence structure in the boundary layer has been initiated. The higher free-stream turbulence was created by fluttering aluminum tags attached to a one-inch square-mesh grid. As for the lower free-stream turbulence level, the data were analyzed to yield higher-order moments of the gradient of the longitudinal velocity fluctuation. The results obtained to date at the higher free-stream turbulence level are rather limited but until more data becomes available it can be inferred that there is little effect on the small-scale structure. Higher-order moments of the gradient of the longitudinal velocity fluctuation measured in the turbulent field downstream of a grid in the three-foot water tunnel at NSRDC showed similar behavior of the small-scale turbulence structure.

The low Reynolds number turbulent boundary layer investigation was started with the design and construction of a flat plate to be used for establishing the boundary layer in the low velocity facility. A traversing system for probing the boundary layer with hot-wire and pressure probes that will supplement the laser velocimeter has also been designed and constructed.

It is planned to further investigate the structure of turbulence in the boundary layer with particular attention given to turbulence quantities to be derived from the three-component probe. The effect of free-stream turbulence level will be further studied, and data will be obtained at higher Reynolds numbers. It is also planned to proceed with the experimental arrangement, and initiate measurements of the turbulence structure in the low Reynolds number boundary layer.

(*h*) **On The Lognormality of The Small-Scale Structure of Turbulence,** F. N. Frenkiel, P. S. Klebanoff, *Boundary Layer Meteorol.* **8,** 2, p. 173, 1975.

321-09732-250-50

DRAG REDUCTION

(*b*) National Aeronautics and Space Administration, Langley Research Center.

(*d*) Experimental and analytical, basic and applied research.

(*e*) Determine the feasibility of obtaining drag reduction by the use of compliant boundaries. The investigation will be conducted on a specially designed flat plate in the 5-ft x 7-ft test section of the NBS dual test section wind tunnel. Several types of compliant surfaces will be examined. Parameters to be varied include the lateral and longitudinal tensions in the surface, the thickness of the substrate, boundary layer thickness, and free-stream velocity. Provisions will be made for obtaining overall surface drag by a direct method. In cases where significant drag reduction is obtained, the affected structure of the boundary layer will be investigated in detail.

(*g*) The construction and polishing of the boundary layer plate with the 4-ft x 4-ft floating reference surface has been completed, and is being assembled in the wind tunnel. A number of modifications were made to the initial design which should significantly improve the operation of the apparatus, and the accuracy and reliability of the experimental measurements. A new technique utilizing suction to apply and monitor the tensions in the compliant surface was developed and tested on a small prototype surface. Measurements were made of the wave speeds in the surface associated with sound excitation utilizing an optical surface monitoring system. A preliminary draft of a technical note concerning these tests has been prepared. The design of a traversing system required for probing the boundary layer structure has been completed.

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U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS, MECHANICS DIVISION, FLUID METERS SECTION, Washington, D. C. 20234. Fillmer W. Ruegg, Section Chief.

322-07242-700-22

AUTOMATED FLOW SYSTEMS

(*b*) Naval Air Systems Command.

(*c*) Dr. David W. Baker, Mechanical Engineer.

(*d*) Experimental; development.

(*e*) Methods and equipment for automatic testing and calibration of aircraft fuel system components are being investigated. At present, during the adjustment and calibration of gas turbine engine fuel controls, an operator manually sets input test parameters which remain stationary during a short time interval when test output data are manually recorded. Adjustments are made on the fuel control under test to bring the performance within specified limits. In this program, a prototype system is being developed in which a minicomputer and digital-oriented control and readout equipment are being used to automate a conventional fuel control test stand installed at NBS. Computer programmed diagnostic aids for the fuel control adjustment process are being developed.

(*g*) A software system has been designed for operation of the prototype test system. A real time operating software system supplied by the computer manufacturer has been modified for the above test system. This system will be capable of simultaneous operation of up to five test stands, and will have both foreground and background capability. Diagnostic programs developed, based on adjustment procedures devised by Bendix Corporation, and a pilot program using unadjusted fuel controls together with the diagnostics indicate the adjustment process can be simplified by requiring fewer operator passes and effectively save operator time and effort.

(*h*) **An Automated Prototype Test System for Aircraft Engine Fuel Controls, Design and Operating Experience,** D. W. Baker, A. L. Koenig, *13th Ann. Tech. Symp.*, Washington, D. C. Chapter, Association for Computing Machinery, June 20, 1974.

An Automated Tune Up, Calibration of Jet Engine Fuel Controls, W. C. Haight, H. W. Hawes, *Automatic Support Systems Symp. for Advanced Maintainability*, IEEE, Oct. 30-Nov. 1, 1974.

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U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS,

MECHANICS DIVISION, HYDRAULICS SECTION, Washington, D. C. 20234. Dr. G. Kulin, Section Chief.

323-07243-060-20

MEASUREMENT OF LEE WAVE DRAG ON SPHERES

(*b*) Office of Naval Research, Dept. of the Navy.
(*c*) Mr. Karl Lofquist, Physicist.
(*d*) Experimental and theoretical; basic research.
(*e*) Measurement of difference in drag between sphere moving in linearly stratified salt water and in fresh water.
(*f*) Experiments completed. Report pending.

323-07824-410-11

SAND TRANSPORT BY WAVES

(*b*) Coastal Engineering Research Center.
(*c*) Mr. Karl Lofquist, Physicist.
(*d*) Experimental and theoretical; basic research.
(*e*) Investigation of the effect of seepage flows, caused by passage of waves over a permeable bed, on the sand transport in the offshore zone.
(*f*) Completed.
(*g*) A positive permeability effect was found, in that sand ripple profiles move in the onshore direction. The velocity of this motion was measured and is described in terms of wave and bed parameters.
(*h*) **An Effect of Permeability on Sand Transport By Waves,** K. E. Lofquist, *CERC Tech. Memo.* (in press).

323-08652-700-00

WATER POLLUTION FLOW MEASUREMENTS (formerly FLUID VELOCITY STANDARDS)

(*d*) Experimental; basic and applied.
(*e*) To develop liquid velocity measurement standards and provide flow measurement support to Government and industry. To evaluate and improve flow measuring instruments and procedures needed in water pollution control and devise means for transferring flow measurement capability from laboratories to field users. To bring on line a new high performance water tunnel to serve as a velocity standard and to do supporting development of tunnel instrumentation in a temporary gravity-flow tunnel. To investigate turbulence effects on bucket-type current meters. To evaluate the performance of rotating element current meters at velocities lower than those at which they are routinely calibrated and under conditions encountered in velocity-area traversing of small conduits for flowrate determination. To evaluate procedures for field calibration of measuring flumes, weirs and other devices by current meter traverses and by other methods, and to identify and quantify errors caused by improper installation of those instruments. To prepare publications aimed at transferring these results and related measurement capability to field users, particularly to industrial dischargers performing compliance monitoring to meet EPA discharge permit requirements. To improve communication among manufacturers, users, regulators and NBS by arranging conferences and working groups.
(*g*) Construction on the high-performance water-tunnel continued. Evaluation of Price and Pygmy meter performance at low velocity in a towing tank was essentially completed, although some fill-in runs will be needed. Experimental determination of wall effects was started. An analytical model of bucket-wheel current meters was developed which permitted an evaluation of the error introduced by a lateral velocity gradient. Errors caused by the presence of the gager's body in the stream during wading measurements were also evaluated analytically. Design of the major components of the 40-ft adjustable-slope open channel was completed and the parts are now being fabricated. Errors in Parshall flume measurements due to common installation and fabrication errors were estimated analytically. A three-inch flume was constructed and experiments started to confirm the assumptions used in the analysis. An investigation of computer modeling of two-dimensional flow measuring flumes was started.
(*h*) **A Guide to Methods and Standards for the Measurement of Water Flow,** G. Kulin, P. R. Compton, *NBS Spec. Publ. 421*, May 1975, GPO Cat. No. C13.10'421.
Discussion by G. Kulin of **Simplified Application of Palmer-Bowlus Flumes,** R. G. Ludwig, J. D. Parkhurst, *J. Water Poll. Cont. Fed.* (in press).

U. S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, GEOPHYSICAL FLUID DYNAMICS LABORATORY, P. O. Box 308, Princeton University, Princeton, N. J. 08540. Dr. Joseph Smagorinsky, Director.

324-08449-450-00

GEOPHYSICAL FLUID DYNAMICS

(*d*) Basic research.
(*e*) Work is directed toward improving understanding of the physical and dynamical processes responsible for structure and variability of the atmosphere and oceans on a wide range of time and space scales. Numerical models are developed and simulation experiments are run on very large computers.
(*h*) **Ocean Tracer Distributions: Part I. A Preliminary Numerical Experiment,** W. R. Holland, *Tellus* **XXIII,** pp. 371-392, 1971.
Response of the Joint Ocean-Atmosphere Model to the Seasonal Variation of the Solar Radiation, R. T. Wetherald, S. Manabe, *Monthly Weather Review* C, 1, pp. 42-59, Jan. 1972.
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A Numerical Calculation of the Circulation in the North Atlantic Ocean, W. R. Holland, A. D. Hirschman, *J. Phys. Oceanog.* **II,** 4, pp. 336-354, Oct. 1972.
Seasonal Variation of Tropical Humidity Parameters, E. M. Rasmusson, in *The General Circulation of The Tropical Atmosphere and Interactions with Extratropical Latitudes*, R. E. Newell, J. W. Kidson, D. G. Vincent, G. J. Boer, Editors, pp. 193-237, 1972, MIT Press, Cambridge, Massachusetts.
Baroclinic and Topographic Influences on the Transport in Western Boundary Currents, W. R. Holland, *Geophys. Fluid Dyn. J.* **IV,** 3, pp. 187-210, Jan. 1973.
The Equatorial Thermocline, S. G. H. Philander, *Deep-Sea Res.* **XX,** 1, pp. 69-86, Jan. 1973.
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Numerical Modeling of the Dynamics and Microphysics of Warm Cumulus Convection, T. L. Clark, *J. Atmos. Sci.* **XXX,** 5, pp. 857-878, July 1973.
A Scheme of Moist Convective Adjustment, Y. Kurihara, *Monthly Weather Review* **CI,** 7, pp. 547-553, July 1973.
Equatorial Undercurrent: Measurements and Theories, S. G. H. Philander, *Reviews of Geophysics and Space Physics* **XI,** 3, pp. 513-570, Aug. 1973.
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Numerical Simulation of the Generation and Breaking of Internal Gravity Waves, I. Orlanski, B. B. Ross, *J.*

Geophys. Res. **LXXVIII,** 36, pp. 8808-8826, Dec. 20, 1973.

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U. S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL OCEAN SURVEY, NATIONAL OCEANOGRAPHIC INSTRUMENTATION CENTER, Rockville, Md. 20852. Gilbert Jaffe, Director.

325-08448-700-00

OCEANOGRAPHIC CURRENT METER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) Test and evaluation of the latest in oceanographic water velocity measurement instrumentation. The program includes transducers utilizing the vortex shedding, electromagnetic and Doppler measurement principles. The purpose of the program is to provide competent evaluation data on the performance of these instruments to the oceanographic community.
(*g*) Preliminary tests were performed on an experimental vortex shedding current meter in 1971 and future tests are planned on a fully operational model. The evaluation of the electromagnetic principle applied to ocean current measurement instruments is underway with products from three different manufacturers undergoing tests. Basic problems were encountered with both flow and tow-type facilities creating excessive noise and calibration problems because of the extreme sensitivity of these instruments. Acoustic Doppler meters are planned for the near future.
(*h*) **Preliminary Tests on a Vortex Shedding Current Meter,** G. Appell, *NOIC Tech. Bull. DE-1002*, Dec. 1971. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09358-700-00

CURRENT METER EVALUATION

(*c*) Robert Farland, Code C632.
(*d*) Investigations, experimental.
(*e*) The distortions introduced into data regarding ocean current velocities acquired by sensors which are implanted with mooring systems characterized by oscillatory vertical motion were investigated. The current meters included two kinds, a Savonius rotor and vane type employing vector averaging (VACM), and the electromagnetic type (EMCM).
(*f*) Completed.
(*g*) The VACM was found to have one major weakness, the speed and direction transducers are incompatible when subjected to vertical velocities. The Savonius rotor is more responsive to vertical motion than the vane; that is, the vane does not track the speed indications of the rotor and the filtering effect of using a vector-averaging technique is ineffective. Because of the sensor housing configurations, it was found that the EMCM was more sensitive than the VACM to vertical oscillations in horizontal flow. It is recommended that caution be exercised when utilizing surface-following taut-wire buoys for measurement of deep ocean currents (> 1000 meters) with the two current meter configurations tested. Additionally, it is recommended that each new class of current meter should be dynamically tested before in-situ measurements are attempted.
(*h*) **Effects of Vertical Motion on Vector Averaging (Savonius Rotor) and Electromagnetic Type Current Meters,** A. N. Kalvaitis, *NOIC Tech. Memo. NOAA-TM-NOS-NOIC-3*, Mar. 1974. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09359-700-54

OCEANOGRAPHIC CURRENT METER EVALUATION

(*b*) Sponsored by the National Science Foundation, International Decade of Ocean Exploration Program.
(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) The evaluation was conducted as part of the Environmental Forecasting Program of the International Decade of Ocean Exploration (IDOE) which includes the Mid-Ocean Dynamics Experiment (MODE). The primary objective of MODE is the investigation of the role of medium-scale geostrophic eddies in the general circulation of the oceans. Quantitative descriptions of the energy content of these phenomena combined with analysis of the energy transfer processes are necessary in order that accurate numerical models that describe the general oceanic circulation may be devised. One of the self-contained ocean current meters that will be used in MODE is the Vector Averaging Current Meter (VACM) developed by the Woods Hole Oceanographic Institution and manufactured by AMF, Inc. Designed to be mounted in a mooring, the instrument computes a vector for each 4 cm of water displacenent to minimize the possibility of data aliasing, processes water displacenent vector components in cartesian coordinates, and records the accumulated components after a predetermined time period.
(*f*) Completed.
(*h*) **Report on the Evaluation of a Vector Averaging Current Meter,** W. E. Woodward, G. F. Appell, *NOIC Tech. Memo. NOAA-TM-NOS-NOIC-1*, July 1973. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09360-700-00

EVALUATION OF CURRENT METERS IN THE FIELD

(*c*) Luther E. Bivins, Code C631.
(*d*) Field investigation, operational reliability.
(*e*) A field evaluation was conducted on several types of ocean current meters, namely the Hydro Products Model 502, the EG&G Model A850, and the Marine Advisers Model Q-15. The work was carried out in 35 feet of water in the Chesapeake Bay. The purpose of the testing was to compare the results obtained from the various instruments operating in the same environment. This Technical Bulletin also includes reliability notes on the General Oceanics Water Sampler and the Bisset-Berman Model 9040 STD Deck Unit Power Supply.
(*h*) **Current Meter Field Evaluation,** W. E. Woodward, *NOIC Tech. Bull. RN-1006*, Mar. 1972. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09361-700-00

ELECTROMAGNETIC CURRENT METER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) Evaluations of several types of electromagnetic current meters were conducted, including the Marsh-McBirney Model 711, the Engineering Physics Co. (EPCO) Model T/S 750B, and two instruments of French design and manufacture, the Comex Mark III and the Schlumberger Model CS 24AD. The design and theory of operation of this type of current meter is discussed in some detail. A table of instrument characteristics is included. Test results

are presented in the form of polar plots. Testing was carried out in the tow facility of the Naval Ship Research and Development Center (NSRDC) at Carderock, Md., as well as in the NOIC flow facility in Washington, D. C.

(*h*) **Electromagnetic Current Meter Evaluation,** *NOIC Tech. Bull. RN-1009*, Mar. 1974. Available from NOAA-NOS-NOIC, Code C633.

325-09362-700-00

RECORDING CURRENT METER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory evaluation was conducted on the Plessey Model MO. 21 Current Meter, principally in terms of the manufacturer's published specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphical form, including polar plots concerning vertical and horizontal directivity response.
(*h*) **Plessey Model MO. 21 Recording Current Meter,** *IFS-73001*, July 1972. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09363-700-00

WAVE RECORDING SYSTEM EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory evaluation was conducted on the Bendix Corporation Model A-2/Q-6 Wave Recording System, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphical form.
(*f*) Completed.
(*h*) **Bendix Corporation Model A-2/Q-6 Wave Recording System,** *IFS-7300*, Aug. 1972. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09364-700-00

LABORATORY AND FIELD WAVE METER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory and field evaluation was conducted on the Alpine Geophysical Associates Model 418 Wave Meter, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphical form.
(*f*) Completed.
(*h*) **Alpine Geophysical Associates Model 481 Wave Meter,** *IFS-74001*, July 1973. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09365-700-00

ELECTROMAGNETIC CURRENT METER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory evaluation was conducted on the Comex Mark III Electromagnetic Current Meter, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphical form.
(*h*) **Comex Mark III Electromagnetic Current Meter,** *IFS-74002*, July 1973. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09366-700-00

WAVE AND TIDE MONITOR EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory and field evaluation was conducted on the Plessey Environmental Systems Model 9010 Wave and Tide Monitor, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed. Results are presented in both tabular and graphical form.
(*f*) Completed.
(*h*) **Plessey Environmental Systems Model 9010 Wave and Tide Monitor,** *IFS-74004*, Feb. 1974. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09367-700-00

CURRENT METER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory and field evaluation was conducted on the AMF, Inc., Vector Averaging Current Meter, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphical form.
(*f*) Completed.
(*h*) **AMF, Inc. Vector Averaging Current Meter,** *IFS-74008*, Apr. 1974. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09368-700-00

PORTABLE WAVE RECORDER EVALUATION

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory and field evaluation was conducted on the Interstate Electronics Corp. Model RS100 Portable Wave Recorder, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphical form.
(*f*) Completed.
(*h*) **Interstate Electronics Corp. Model RS100 Portable Wave Recorder,** *IFS-74009*, May 1974. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

325-09369-700-00

EVALUATION OF RECORDING CURRENT METERS

(*c*) Luther E. Bivins, Code C631.
(*d*) Investigations, evaluation.
(*e*) A laboratory evaluation was conducted on the Aanderaa Models RCM-4 and RCM-5 Recording Current Meters, principally in terms of the manufacturer's specifications. Technical characteristics and the operation of the instrument are discussed in some detail. Results are presented in both tabular and graphic form.
(*f*) Completed.
(*h*) **Models RCM-4 and RCM-5 Aanderaa Recording Current Meters,** *IFS-75002*, July 1974. Available from NOAA-NOS-NOIC, Code C633, Rockville, Md. 20852.

U. S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL WEATHER SERVICE, Silver Spring, Md. 20910. Dr. Robert A. Clark, Associate Director of National Weather Service (Hydrology).

326-05664-810-00

STREAMFLOW FORECASTING RESEARCH

(*c*) Dr. Eugene L. Peck, Director, Hydrologic Research Laboratory.
(*d*) Theoretical and field; applied research.
(*e*) Research covering a wide range of hydrologic investigations is conducted with the primary objective to improve the operational river forecasting service. Activities include development and testing of conceptual models for continuous simulation of streamflow; improved methods for modeling the snowmelt runoff process; remote measure-

ment of water equivalent of snow cover by aerial surveys of natural gamma radiation from the soil; development of numerical routing techniques; improved methods for measurement of precipitation including radar.

(*g*) Conceptual models are being applied to operational forecasting. Aerial gamma radiation technique has been field tested. An implicit difference solution of the unsteady flow equations has been analyzed to determine its numerical properties and is currently being tested for routing floods in the lower Mississippi and Columbia Rivers. Techniques are being developed and evaluated for the operational application of digital radar data to river stage and flash flood forecasting (1974, 1975).

(*h*) **The Operational Use of Digital Radar Data for Flash Flood Monitorings,** D. R. Greene, R. A. Clark, *Flash Floods Symp. IAHS-AISH Pub. 112*, Paris, France, pp. 100-105, Sept. 1974.

Hydrologic Application of Digital Radar Data, D. R. Greene, Preprints *16th Radar Meteorology Conf.*, Amer. Meteorol. Soc., Houston, Tex., Apr. 1975.

National Weather Service River Forecast System, Snow Accumulation and Ablation Model, E. Anderson, *NOAA NWS Tech. Memo Hydro-17*, U. S. Dept. of Commerce, Silver Spring, Md., Nov. 1973.

Effects of Time Step Size in Implicit Dynamic Routing, D. L. Fread, *Water Resources Bulletin, Amer. Water Resources Assoc.* **9,** 2, Paper 73020, Apr. 1973.

Computation of Stage-Discharge Relationships Affected by Unsteady Flow, D. L. Fread, *Water Resour. Bull.*, Amer. Water Resources Assoc., Feb. 1975.

Technique for Implicit Dynamic Routing in Rivers with Tributaries, D. L. Fread, *Water Resour. Res.* **9,** 4, Aug. 1973.

Numerical Properties of Implicit Four-Point Finite Difference Equations of Unsteady Flow, D. L. Fread, *NOAA NWS Tech. Memo Hydro-18*, U. S. Dept. of Commerce, Silver Spring, Md., Mar. 1974.

Accuracy of Precipitation Measurements for Hydrologic Modeling, *Water Resour. Res.* **10,** 4, Aug. 1974.

National Weather Service River Forecasting System, J. C. Monro, E. A. Anderson, *J. Hydraul. Div., ASCE* **100,** HY15, May 1974.

Lake Ontario Snowfall Observational Network for Calibrating Radar Measurement, E. L. Peck, L. W. Larson, J. W. Wilson, *Advanced Concepts and Techniques in the Study of Snow and Ice Resources*, Natl. Acad. Sci., Monterey, Calif., Dec. 2-6, 1973.

National Weather Service River Forecast System, Forecast Procedures, Staff, Hydrologic Research Laboratory, *NOAA NWS Tech. Memo. Hydro-14*, U. S. Dept. of Commerce, Silver Spring, Md., Dec. 1972.

326-06154-810-00

HYDROMETEOROLOGICAL RESEARCH FOR DESIGN CRITERIA

(*b*) Soil Conservation Service, U. S. Department of Agriculture; Corps of Engineers, Department of the Army, U. S. Department of Defense.

(*c*) Mr. John F. Miller, Meteorologist, Chief, Water Management Information Division.

(*d*) Largely theoretical; basic and applied.

(*e*) Preparation of estimates of probable maximum precipitation, meteorological conditions for maximum snow accumulation and melting, hurricane wind fields, and rainfall intensity-frequency for design of spillways and other water-control structures and programs.

(*g*) Results are provided in the publications listed under (h).

(*h*) **Precipitation Frequency Atlas of Western United States,** J. F. Miller, R. H. Frederick, R. J. Tracey, *NOAA Atlas 2, I, Montana; II, Wyoming; III, Colorado; IV, New Mexico; V, Idaho; VI, Utah; VII, Nevada; VIII, Arizona; IX, Washington; X, Oregon; XI, California;* U. S. Dept. of Commerce, Silver Spring, Md., 1973.

Time Distribution of Precipitation in 4- to 10-Day Storms – Arkansas and Canadian River Basins, R. H. Frederick, *NOAA Tech. Memo. NWS HYDRO 15*, U. S. Dept. of Commerce, Silver Spring, Md., 45 pages, Mar. 1973.

Meteorological Criteria for Extreme Floods for Four Basins in the Tennessee and Cumberland River Watersheds, F. K. Schwarz, *Hydrometeorol. Rept. 47*, U. S. Dept. of Commerce, Silver Spring, Md., 59 pages, May 1973.

Probable Maximum Precipitation and Snowmelt Criteria for Red River of the North Above Pembina, and Souris River Above Minot, North Dakota, J. T. Riedel, *Hydrometeorol. Rept. 48*, U. S. Dept. of Commerce, Silver Spring, Md., 69 pages, May 1973.

Weather Situations Associated with Floods During 1972, J. F. Miller, *Highway Research Record 479*, Natl. Res. Council, Washington, D. C., pp. 5-11, 1973.

Probable Maximum Precipitation – The Concept, Current Procedures and Outlook, J. F. Miller, *Proc. 2nd Intl. Symp. on Hydrology*, Sept. 11-13, 1972, *Water Resources Publ.*, Fort Collins, Colo., pp. 50-61, 1973.

Manual for Estimation of Probable Maximum Precipitation, World Meteorological Organization, *Operational Hydrology Rept. 1, WMO 332*, World Meteorological Organization, Geneva, Switzerland, 190 pages, 1973.

A Proposal for Estimating Tropical Storm Probable Maximum Precipitation for Sparse Data Regions, F. K. Schwarz, *Proc. 2nd Intl. Symp. on Hydrology*, Sept. 11-13, 1972, *Water Resources Publ.*, Fort Collins, Colo., pp. 62-82, 1973.

Some Procedures for Determining Extreme Precipitation Criteria, J. T. Riedel, *Proc. Engrg. Foundation Conf. on Inspection, Maintenance, and Rehabilitation of Old Dams*, Pacific Grove, Calif., Sept. 23-28, 1973, ASCE, New York, N. Y., pp. 284-301, 1974.

The Black Hills-Rapid City Flood of June 9-10, 1972: A Description of the Storm and Flood, F. K. Schwarz, L. A. Hughes, E. M. Hansen of NWS, and M. S. Petersen, D. B. Kelly of GS, *Geol. Survey Prof. Paper 877*, U. S. Dept. of the Interior (in preparation).

Hurricane Agnes: Rainfall and Floods June-July 1972, J. L. Patterson, J. F. Bailey, J. L. H. Paulhus, *Geol. Survey Prof. Paper*, U. S. Dept. of the Interior (in preparation).

Floods of March-April 1973 in Southeastern United States, G. W. Edelen, Jr., J. F. Miller, *Geol. Survey Prof. Paper*, U. S. Dept. of the Interior (in preparation).

Mississippi Basin Flood of Spring 1973, E. H. Chin, J. Skelton, *Geol. Survey Prof. Paper*, U. S. Dept. of the Interior (in preparation).

Some Climatological Characteristics of Hurricanes and Tropical Storms, Gulf and East Coasts of the United States, F. P. Ho, R. W. Schwerdt, H. V. Goodyear, *NOAA Tech. Rept. NWS*, U. S. Dept. of Commerce (in preparation).

326-08459-420-58

TIDAL SURGE FREQUENCY DISTRIBUTION – ATLANTIC AND GULF COASTS

(*b*) Department of Housing and Urban Development.

(*c*) Mr. John F. Miller, Meteorologist, Chief, Water Management Information Division.

(*d*) Largely applied research; some basic and theoretical development.

(*e*) Tidal frequency analyses for the open coast along the Atlantic and Gulf coasts of the United States. The objective is to define the frequency of all possible tidal stages, including the effects of the astronomically induced tide on the surges that can be generated by all possible types of severity of storms, including the more rare and severe hurricanes. Existing bay models are adapted to provide tide frequency values at the heads of bays and estuaries and behind barrier islands. These frequency estimates are used by the Federal Insurance Administration as the basis for setting rates in implementing federally sponsored insurance against the hazards or destruction by floods.

(*g*) Detailed tide frequency values have been reported to the Federal Insurance Administration and in the reports listed in (h).

(*h*) **Some Climatological Characteristics of Hurricanes and Tropical Storms, Gulf and East Coasts of the United States,** F. P. Ho, R. W. Schwerdt, H. V. Goodyear, *NOAA Tech. Rept. NWS*, U. S. Dept. of Commerce (in preparation).
Storm Tide Frequencies on the South Carolina Coast, V. A. Myers, *NOAA Tech. Rept. NWS*, U. S. Dept. of Commerce (in preparation).
Estimation of Hurricane Storm Surge in Apalachicola Bay, Florida, J. E. Overland, *NOAA Tech. Rept. NWS*, U. S. Dept. of Commerce (in preparation).
Storm Tide Frequency Analysis for the Coast of Georgia, F. P. Ho, *NOAA Tech. Memo NWS HYDRO-19*, U. S. Dept. of Commerce, 28 pages, Sept. 1974.
Storm Tide Frequency for the Gulf Coast of Florida from Cape San Blas to St. Petersburg Beach, E. P. Ho, R. J. Tracey, *NOAA Tech. Memo. NWS HYDRO*, U. S. Dept. of Commerce, (in preparation).

U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, DIVISION OF GENERAL RESEARCH, Attention 1530, Denver Federal Center, Denver, Colo. 80225. Howard J. Cohan, Division Chief. (Address all inquiries to Division Chief.)

327-0364W-230-00

MECHANICS AND PREVENTION OF CAVITATION EROSION

See Water Resources Research Catalog **8,** 8.0115.

327-0365W-360-00

BAFFLED SPILLWAY ENERGY DISSIPATOR

See Water Resources Research Catalog **8,** 8.0166.

327-0366W-700-00

WATER MEASUREMENT

See Water Resources Research Catalog **8,** 4.0087.

327-0367W-210-00

PIPELINE AND TUNNEL HYDRAULICS

See Water Resources Research Catalog **8,** 7.0061.

327-04794-360-00

VERTICAL STILLING WELL

(*d*) Experimental, theoretical; applied research.
(*e*) A Plexiglas model was constructed to obtain optimum size and internal configuration of vertical stilling wells for a wide range of discharges. Promising designs were further tested in a larger vertical stilling well model.
(*f*) Completed.
(*g*) General design criteria for the VSW with a standard sleeve valve using dimensionless parameters related to sizing the stilling well based on design discharge, Q, and valve diameter, D, was established.
(*h*) **Hydraulic Model Studies of Vertical Stilling Wells,** P. H. Burgi, *Rept. REC-ERC 73-3*, Feb. 1973.

327-05343-060-00

STRATIFIED FLOW

(*d*) Experimental and theoretical; applied research.
(*e*) A laboratory flume is being used to study the mechanism of selective withdrawal from stratified reservoirs. Temperature difference, monitored with thermistors, is being used to induce stratification.
(*g*) A tentative theory for use in designing selective outlets and a computer program for its solution were developed and examined with experimental data.
(*h*) **Hydraulics of Stratified Flow – Final Report – Selective Withdrawal from Reservoirs,** P. L. Johnson, *Rept. REC-ERC 74-1*, Jan. 1974.

327-06321-340-00

DRAFT TUBE SURGES

(*d*) Theoretical and experimental; basic and applied research.
(*e*) Surging flow in draft tubes of Francis turbines causes rough operation and often produces power swings. The surging flow is produced by vortex breakdown, creating a stable unsteady flow condition. The purpose of the project is to investigate the basic nature of draft tube surging, to correlate model test and field test data, and to investigate the addition of appurtenances in the draft tube and changes in the draft tube geometry itself as a means of eliminating or reducing the magnitude and range or occurrence of the surging.
(*g*) In a laboratory air model, surge data were obtained for over 50 draft tube shapes, including draft tube models, straight circular cylinders, truncated diverging cones, and circular cross-section elbows. The studies show that the degree of divergence of the draft tube throat is the most significant geometric feature affecting surging characteristics. Bends and length have lesser influence. Increasing the draft tube throat expansion angle generally reduces the range of surging as well as reducing the amplitude of surging. Good comparison was obtained between results of the laboratory studies and manufacturer's model tests for the Grand Coulee pump-turbine draft tube. The swirl momentum method has not been refined to allow general prediction of the limits of the surging range.
(*h*) **Model and Prototype Turbine Draft Tube Surge Analysis by Swirl Momentum Method,** U. J. Palde, *IAHR Symp.*, Vienna, Austria, Sept. 1974.

327-06323-340-00

GRAND COULEE THIRD POWERPLANT PENSTOCKS

(*d*) Experimental; for design.
(*e*) A 1:41-75-scale model aided in the development of the entrances and elbows for the 40-foot diameter penstocks.
(*f*) Completed.
(*g*) A penstock entrance that is much smaller and shorter than entrances designed by current criteria was found to have satisfactory flow and pressure conditions and a very small head loss coefficient. The tests also indicate that an accelerating elbow just upstream of the generator entrance will be equally efficient with a curvature radius equal to either 2-1/2 or 3-1/2 times the penstock diameter.
(*h*) **Hydraulic Model Studies for the Penstocks for Grand Coulee Third Powerplant,** T. J. Rhone, *Rept. REC-ERC 74-12*, Aug. 1974.

327-07018-320-00

MAIN CANAL BACON SIPHON AND TUNNEL

(*d*) Experimental; for design.
(*e*) A 1:49.8-scale model was used to aid in developing the design of the entrance and exit canal transitions to the two siphons and to determine the size of the main canal and the design of the canal bifurcations both upstream and downstream of the siphons.
(*f*) Completed.
(*g*) Wave suppressors were developed for use with the two exit transitions to provide a smoother water surface and more uniform flow distribution in the canal downstream. Since one of the siphons was an existing structure, the two wave suppressors developed were not alike.
(*h*) **Hydraulic Model Studies of the Canal Structures Adjacent to Bacon Siphon, and Tunnel, Columbia Basin Project, Washington,** G. L. Beichley, *Rept. REC-ERC 72-22*, July 1972.

327-07019-350-00

FLOW AERATOR DOWNSTREAM OF SLIDE GATES TO PROTECT AGAINST CAVITATION EROSION

(*d*) Experimental; for design.

(*e*) A slide gate model is used to aid in the development of methods to induce air into the flow from existing slide gate installations and for general use in proposed new installations.
(*f*) Completed.
(*g*) Air supply slots in the walls together with a floor deflector to lift the jet from the floor at the gate frame were developed for the existing outlet works at Palisades Dam and the existing auxiliary outlet works at Navajo Dam. An offset away from the flow in the conduit floor and walls of proposed outlets at Pueblo Dam, Crystal Dam (earth design), and Teton Dam were developed. General design criteria were established for use in slide gate outlet designs at future installations.
(*h*) **Hydraulic Model Studies of Chute Offsets, Air Slots, and Deflectors for High-Velocity Jets,** G. L. Beichley, *Rept. REC-ERC 73-5*, Mar. 1973.

327-07022-340-00

GRAND COULEE PUMP-TURBINE INTAKE AND TRANSITION

(*d*) Experimental; for modification.
(*e*) Laboratory studies are continuing to determine the benefits which could be derived by lowering the floor of the Banks Lake Feeder Canal.
(*f*) Completed.
(*g*) The conduit exits, designed and built for pumped flow only, must be modified to operate satisfactorily as inlet-outlet structures for the pump-turbine concept. A satisfactory design developed by model study included reshaping 78 feet of the conduit exits, and adding one vortex-suppressing wing wall.
(*h*) Report in preparation.

327-07025-700-00

SUPPRESSED RECTANGULAR WEIR STUDY

(*d*) Experimental; applied research.
(*e*) Laboratory studies were performed on a 4-foot wide weir box turnout structure for irrigation use with closed pipe inflow. The purpose of the study was to determine the shortest box and the best stilling baffle arrangement to produce a reasonably smooth water surface and uniform velocity profile upstream of a suppressed rectangular weir for discharges up to 10 cfs.
(*f*) Completed.
(*g*) The minimum length of the stilling box and a satisfactory baffle arrangement were determined which provided approach conditions that were suitable for establishing a rating curve for the weir up to about 12 cfs. The rating curve differs from accepted standard suppressed weir formulas because of the nonstandard approach conditions and method of measuring head. The Kindsvater-Carter method has been used to fit an equation to the rating curve data.
(*h*) **Hydraulic Laboratory Studies of a 4-Foot Wide Weir Box Turnout Structure for Irrigation Use,** U. J. Palde, *Rept. REC-ERC 72-31*, Sept. 1972.

327-07028-350-00

AUBURN SPILLWAY GATE STUDY

(*d*) Experimental; design.
(*e*) a 1:24-scale model was built to study the 11- by 17-foot downstream seal fixed-wheel gates for the spillway at Auburn Dam. The model conduit was offset away from the flow downstream of the gate frame to provide aeration to the flow boundary. In addition, a 1:3.6-scale sectional model was built to study pressures on the flow surfaces in the immediate vicinity of the gate slot. Finally, a second 1:24-scale model is to be built to develop an approach conduit to the gate that will not require a steel lining. Contraction of the approach conduit throughout its length should maintain positive pressures on the flow boundaries and therefore eliminate the need for a lining.
(*g*) An upstream seal concept was first tested and then abandoned when it was found that heavy flow into the large gate slots cound not be eliminated.

327-07030-320-00

CANAL AUTOMATION

(*d*) Experimental development; applied research.
(*e*) Continue the development of controls for automation of water distribution systems.
(*g*) A downstream controller was successfully operated in the laboratory and installed on a canal for satisfactory operation of canal gates. Experiments on a constant head turnout gate showed automation feasibility.
(*h*) **Water Systems Automation – Current Information on Automation of Reclamation Water Systems,** July 1973.

327-07032-860-00

REAERATION OF STREAMS AND RESERVOIRS

(*d*) Experimental and theoretical; applied research.
(*e*) Emphasis is being placed on development of equipment and methods for reaeration of large volumes of water. Comparison of efficiencies will be emphasized. The reaeration and supersaturation potential of hydraulic structures is also being studied.
(*g*) A state-of-the-art review and a survey of western regional needs for reaeration were completed. An interdisciplinary team was formed to plan and manage the reaeration research program. A hydraulic gun-type device and an air diffuser were used at different sites in an attempt to locally destratify and aerate portions of large reservoirs. Both attempts met with limited success. Attention is now centering on propellor devices that are either mechanically or compressed air driven, and on biological effect of reaeration and destratification. A program to monitor dissolved gas levels created by prototype hydraulic structures is ongoing. An analysis that predicts the dissolved gas levels created by hydraulic structures has been developed.
(*h*) **Biological Effects of Artificial Destratification and Aeration in Lakes and Reservoirs – Analysis and Bibliography,** D. Toetz, J. Wilhin, R. Summerfelt, *Rept. REC-ERC 72-33*, Oct. 1972.

327-07035-350-00

AUBURN DAM SPILLWAYS

(*d*) Experimental; design.
(*e*) A 1:72 model is used to study flow conditions in the chutes, stilling basins, and river channel. The service spillway is located on the left abutment and discharges into a hydraulic jump stilling basin. The emergency spillway on the right abutment terminates in a flip bucket. Each spillway discharges up to 160,000 cfs through controlled orifices located up to 150 feet below the maximum water surface. The model is also being used to determine optimum sequencing of the orifices.
(*f*) Completed.
(*g*) Tests confirmed that the hydraulic jump energy dissipator for the service spillway was satisfactory. Testing was continued to develop alternate means for distributing the flow from the service spillway. Efforts have been directed toward terminating the chute about midway between the orifice spillway and the river channel. A flip-type bucket is being developed to deflect the flow into an excavated plunge pool in the river channel.
(*h*) Report in preparation.

327-08461-350-00

SCOGGINS DAM AERATOR OUTLET TO THE FISH TRAP

(*d*) Experimental; applied research.
(*e*) A 1:3.33-scale model aided in the development of an enclosed-basin type energy dissipator for a 20-inch horizontal cylinder (fixed-cone) control valve used to aerate the flow into a constant head orifice structure before distributing the flow to various areas of the fish trap.
(*f*) Completed.
(*g*) An enclosed basin with flared walls, floor, and ceiling to intercept the cone-shaped jet followed by a 45° deflector on walls and ceiling with baffle blocks on floor was developed to contain the jet and dissipate the energy be-

fore allowing the flow to enter the constant head orifice structure. The purpose of using this type of valve and energy-dissipator was to expose the flow to a considerable amount of air for the absorption of oxygen into the flow before delivering it to the fish trap.
(*h*) **Hydraulic Model Studies of Scoggins Dam Fishtrap Aeration and Supply Structure,** G. L. Beichley, *Rept. REC-ERC 72-27*, July 1972.

327-08462-320-00

TETON CANAL OUTLET WORKS

(*d*) Experimental; for design.
(*e*) A 1:5.66-scale model aided in the development of a 3-diameter expansion energy dissipator for flow from a 20-inch jet flow gate.
(*f*) Completed.
(*g*) Results provided a discharge rating of the gate, losses through the system, and incipient cavitation coefficients. It was determined that high back pressure on the system reduced the potential for cavitation.
(*h*) **Hydraulic Model Studies of the Teton Canal Outlet Works Energy Dissipator,** T. J. Isbester, *REC-ERC 74-16*, Oct. 1974.

327-08468-860-00

PREDICTION OF TEMPERATURES IN RESERVOIRS

(*d*) Theoretical; applied research.
(*e*) Several available mathematical models are being evaluated for applications in predicting temperature patterns in existing and future reservoirs. Predictions are being compared with field data on existing reservoirs for verification of the models.
(*h*) **Mathematical Simulation of Temperatures in Deep Impoundments (Verification Tests of the Water Resources Engineers, Inc., Model – Horsetooth and Flaming George Reservoirs),** D. L. King, J. J. Sartoris, Nov. 1973.

327-08469-360-00

PLUNGE BASINS FOR SLIDE GATE OUTLETS

(*d*) Experimental; applied research.
(*e*) Model studies are being conducted using a 1-inch by 1-inch slide gate to determine the depth, breath, and length of scour in gravel from which to prepare design criterion for riprap lined plunge basins.
(*f*) Completed.
(*g*) Dimensionless guidelines for riprap lined plunge basins for free falling jets were developed. Parameters considered in the study as they affect the depth, length, and width of the plunge basin are height of the outlet above tailwater, pressure head on outlet, outlet size, tailwater depth, and size of riprap.
(*h*) **Hydraulic Model Studies of Plunge Basins for Jet Flow,** P. L. Johnson, *Rept. REC-ERC 74-9*, June 1974.

327-08471-340-00

AUBURN DAM BUTTERFLY VALVE STUDIES

(*d*) Experimental; for design.
(*e*) Laboratory studies were initiated to compare the hydraulic losses caused by butterfly valves installed as guard valves upstream from turbines. The study will compare valves with geometrically similar leafs but with different body configurations and different locations with respect to the turbine.
(*f*) Completed.
(*g*) Model studies were made to determine the head loss through the valve with the leaf fully opened for a valve with a straight-through body, and one with an expanding-contracting body so constructed that the flow passage area through the valve gradually decreases in the direction of flow. Head loss coefficient for the valve with the expanding-contracting body was about 71 percent less than the loss coefficient for the valve with the straight-through body. Discharge and torque coefficient charts were determined for the valve with the expanding-contracting body.
(*h*) **Discharge and Torque Characteristics, 198-Inch Butterfly Valve, Auburn Dam,** D. Colgate, *REC-ERC 73-8*, May 1973.

327-08472-750-00

ATMOSPHERIC SIMULATION

(*d*) Experimental; research.
(*e*) A study to determine feasibility of using salt water density gradients in a model to represent atmosphere and to check effect of vertical distortion on scaling.
(*f*) Discontinued.
(*g*) The technique, using Couette flow, of simulating atmosphere with a stratified liquid was satisfactory. The results were verified by observations of field data. An optical method of determining stratification densities was developed during the study.
(*h*) Report in draft form.

327-08473-390-00

AUTOMATIC CONSTANT HEAD ORIFICE TURNOUT

(*d*) Experimental; applied research.
(*e*) Tests to determine the operational characteristics of component parts of a system that delivers constant discharge under a variable upstream head with a constant differential maintained on the orifice measuring gate by means of a motorized downstream control gate.
(*f*) Completed.
(*g*) Feasibility of automation was demonstrated.
(*h*) No formal report to be issued.

327-08474-890-00

ICE EMBRYO NOZZLES FOR CLOUD SEEDING

(*d*) Experimental; applied research.
(*e*) Miniature supersonic nozzles were developed and tested for generation of ice nuclei from compressed air, for use in seeding super-cooled clouds and fog. The study concentrated on designing nozzles that would produce a satisfactory number of nuclei and then grow these nuclei to a large enough size so that they will survive in ambient temperatures approaching 0 °C.
(*f*) Completed.
(*g*) Results show satisfactory production (10^{12} to 10^{13} nuclei per gram of air) of surviving nuclei for cloud temperature below −5 °C.
(*h*) Report in draft form.

327-08475-890-00

SPRAY NOZZLES FOR CLOUD SEEDING AND OTHER APPLICATIONS

(*d*) Experimental; applied research.
(*e*) Commercial devices and laboratory developed devices are being tested for use in spraying hygroscopic liquids for cloud seeding and for spray drying and other miscellaneous applications.
(*f*) Suspended.
(*h*) **Research and Development of Nozzles for Spray Applications – First Progress Report,** D. L. King, T. J. Isbester, *REC-ERC 74-4*, Mar. 1974.

327-08476-350-00

CRYSTAL ARCH DAM OUTLET WORKS

(*d*) Experimental; design.
(*e*) A 1:13.6-scale model of the outlet works was used to study the flow conditions in the vertical inlet tower, the horizontal bellmouth entrance from the tower to the outlet conduit, and the jet flow gate which discharges submerged to the plunge pool.
(*f*) Completed.
(*g*) A vortex appearing in the preliminary horizontal bellmouth transition from the intake towers to the 54-inch outlet works conduits was eliminated by raising the floor of the intake tower closer to the invert of the bellmouth. The design was subsequently improved by using one intake

tower for both outlet conduits placed at the same elevation. Discharge coefficients for the submerged 48-inch jet flow gates were obtained.

(*h*) **Hydraulic Model Studies of Crystal Dam Spillway and Outlet Works – Colorado River Storage Project,** P. H. Burgi, S. Fujimoto, *Rept. REC-ERC 73-22*, Dec. 1973.

327-08477-350-00

CRYSTAL ARCH DAM SPILLWAY

(*d*) Experimental; design.

(*e*) 1:36-scale model was used to aid in the development of a flip-type spillway and plunge pool design.

(*f*) Completed.

(*g*) The exit configuration of the flip bucket spillway was modified by extending the 15-foot radius beyond the bucket invert to a 4:1 tangent at the bucket lip. The modified bucket adequately flipped the spillway jet into a plunge pool. A 15-foot high deflector wall was placed at the downstream end of the excavated rock plunge pool to deflect the high energy spillway jet from the 3 to 1 riprapped slope leading to the downstream river channel. Discharge coefficients for the spillway were obtained.

(*h*) **Hydraulic Model Studies of Crystal Dam Spillway and Outlet Works – Colorado River Storage Project,** P. H. Burgi, S. Fujimoto, *Rept. REC-ERC 73-22*, Dec. 1973.

327-09379-390-00

HAVASU PUMPING PLANT INTAKES AND SUCTION TUBES

(*d*) Experimental; design.

(*e*) A 1:9.4-scale model was used to study flow conditions in the approach channel to the pumping plant, through the suction tube intakes, and through the suction tubes. Each of the six units in the plant has a maximum discharge of 500 ft^3/s with a vertical lift of approximately 800 feet. The pumps have a submergence of approximately 70 feet with a resulting suction tube length of approximately 140 feet. The effects of the sequence of pump operation and the intake water surface elevation were considered.

(*f*) Completed.

(*g*) Tests confirmed that the suction tube design was satisfactory, yielding quite uniform flow with only slight rotation at the pump eye. For the two suction tube intakes studies (gate sections of 9 feet by 9 feet and 9 feet by 12.5 feet) no difference was observed in their hydraulic performance. At various operating conditions vortex tendencies were observed above the suction tube intake. Placement of the trash-racks on the intakes reduced the intensity of the vortices and eliminated the potential for air to be drawn into the suction tubes. A unit sequencing was found to minimize adverse flow patterns in the intake channel.

(*h*) Report in preparation.

327-09380-340-00

TWIN LAKES PUMPED STORAGE PROJECT

(*d*) Experimental; design.

(*e*) Two models are being used to determine the effect of the pumping and generating flow on a natural lake used as the afterbay during the generating cycle and forebay for the pumping cycle. A distorted model (1:100 vertical - 1:600 horizontal) has been made of the recipient lake and a connected companion lake which are thermally stratified and the effect of several weeks of plant operation on the stratification is being determined. The second model is undistorted on a 1:100 scale and contains the pumping-generating plant and a section of the recipient lake. This model is to determine the best configuration for the channel between the plant and lake to prevent the flow from disturbing glacial flow deposits on the bottom of the lake.

327-09381-360-00

HYDRAULIC MODEL STUDIES OF CANYON FERRY DAM STILLING BASIN

(*d*) Experimental.

(*e*) Determine the cause and recommend a solution for the deposit and movement of riverbed material into the Canyon Ferry Dam spillway stilling basin.

(*f*) Completed.

(*g*) Tests indicated that movement of the riverbed material into the basin resulted from operation of the river outlets at discharges greater than 3,000 ft^3/s. Model tests estimated the spillway discharge and time of operation required to clean riverbed material from the basin. These model criteria were subsequently confirmed by prototype tests.

(*h*) **Hydraulic Model Studies of Canyon Ferry Dam Spillway Stilling Basin,** P. H. Burgi, in preparation.

327-09382-350-00

STEWART MOUNTAIN SPILLWAY

(*d*) Experimental; design.

(*e*) A 1:72 model was used to study flow patterns across a rock surface downstream from the spillway chute. The spillway, which is 265 feet wide and 450 feet long, will pass a maximum discharge of 140,000 ft^3/s. The flow returns to the river from the spillway chute by passing over the granite terrain. When the chute was constructed in 1936 it was thought that the rock was adequate to prevent significant erosion. This has not proven to be the case and now the chute structure is being compromised. The study was done to find a solution that would reduce and protect against adverse hydraulic action on the rock.

(*f*) Completed.

(*g*) Tests developed an excavated topography that eliminated adverse hydraulic action at poor rock zones near the chute structure. Impact pressures and flow velocities were determined for use in the design of protective surfacing.

(*h*) Report in preparation.

327-09383-360-00

LOW FROUDE NUMBER STILLING BASINS

(*d*) Experimental, applied research.

(*e*) Studies are being performed to generalize a hydraulic jump-type stilling basin for spillway flows having an entering Froude number less than 4.5. Studies will be directed to determining dimensions and appurtenances that will provide effective energy dissipation in the basin and smooth water surface downstream from the basin. Parameters will be reduced to dimensionless relationships and will be a supplement to the USBR Monograph No. 25, "Hydraulic Design of Spillways and Energy Dissipators."

(*g*) A basin has been developed for a specific project with Froude number of about 3.0. Studies are continuing for a different slope on the entrance chute and other Froude numbers.

327-09384-390-00

ICE RESEARCH

(*d*) Experimental, field research.

(*e*) To improve designs and to reduce expenses of operating and maintaining water resource projects in cold regions. Present areas of investigations include shallow river intake designs, frost action, and coatings to reduce ice adhesion to trashracks exposed to the atmosphere.

(*h*) **Prevention of Frazil Ice Clogging of Water Intakes by Application of Heat,** T. H. Logan, *Rept. REC-ERC 74-15*, Sept. 1974.

Design and Operation of Shallow River Diversions in Cold Regions, R. B. Hayes, *Rept. REC-ERC 74-19*, Sept. 1974.

327-09385-210-00

HORIZONTAL MULTIJET SLEEVE VALVE

(*d*) Basic research; development.

(*e*) The multijet sleeve valve has potential for use in pressure systems of municipal and industrial water supply lines for dissipation of pressure heads up to 500 feet. The investigation involves sizing the multijet ports and stilling chamber and determining the discharge coefficients for the valve and stilling chamber.

(*g*) A multijet sleeve has been developed where a combination of nozzles and slots are used to efficiently pass the design flow.

327-09386-350-73

HYDRAULIC MODEL STUDIES OF THE LOW LEVEL OUTLET WORKS, LG-2 DEVELOPMENT, QUEBEC, CANADA

(*b*) James Bay Energy Corporation.
(*d*) Experimental; design.
(*e*) Studies were performed to develop a high head energy dissipator for the low level outlet works for the LG-2 power development in the province of Quebec, Canada.
(*f*) Completed.
(*g*) An energy dissipator was developed that included a deflector ring and baffle piers in a steel-lined oval section downstream from two 96-inch Howell-Bunger valves. Data were obtained for computation of required tunnel air supply and for structural design of the deflector ring and energy dissipator walls.
(*h*) **Hydraulic Model Studies of the Low Level Outlet Works, LG-2 Development, Quebec, Canada,** D. Colgate, *Rept. REC-ERC 74-3*, Jan. 1974.

327-09387-350-00

HYDRAULIC MODEL STUDIES OF O'SULLIVAN DAM SPILLWAY

(*d*) Experimental; design.
(*e*) Studies were made to verify the design of the spillway, approach channel and spillway chute.
(*f*) Completed.
(*g*) The preliminary approach channel was modified to improve entrance flow conditions. Operating criteria were established for the spillway gates to assure acceptable flow conditions in the spillway chute. Discharge rating curves are presented relating spillway discharge capacity to pier location upstream of the crest, at the crest, and downstream from the crest.
(*h*) **Hydraulic Model Studies of O'Sullivan Dam Spillway, Columbia Basin Project,** P. H. Burgi, *Rept. REC-ERC 73-15*, Sept. 1973.

327-09388-850-00

McCLUSKY CANAL FISH SCREEN

(*d*) Experimental; design.
(*e*) A full scale sectional model was used to study the performance of a screen structure designed to stop the passage of fish, fish eggs, and fish larvae. Laboratory tests were conducted to optimize the screen size while maintaining adequate screening and self-cleaning. The prototype structure will pass a maximum design discharge of 1,950 ft^3/s.
(*g*) The purpose of the study was accomplished and the prototype structure is now under construction.
(*h*) Report in preparation.

327-09389-390-34

HYDRAULIC MODEL STUDIES FOR BACKFILLING MINE CAVITIES

(*b*) U. S. Bureau of Mines.
(*c*) E. J. Carlson, Code 1532.
(*d*) Experimental; applied research.
(*e*) Hydraulic models of an idealized coal mine were tested to demonstrate the pattern of deposition of sand material by pumping a slurry of fine sand and water into the mine cavity. A distorted geometrical scale with the horizontal scale 1:24 (model to prototype) and vertical scale 1:8 was used first to give transport velocities in the model equal to transport velocities in the prototype. An undistorted model with a scale 1:24, was also tested in which transport velocities were not equal in the model and prototype. Prototype sand, 0.14 mm mean diameter, was used for backfill material in all model tests. Tests were made to simulate the following mine cavity conditions: level floor with cavity submerged; level floor with cavity dry; sloping floor with bottom of injection hole submerged; sloping floor with bottom of injection hole above the water surface; corridor between pillars partially blocked and totally blocked; and solid walls on one and two adjacent sides of a rectangular section of pillars surrounding the injection hole.
(*g*) Approximate bearing strengths of backfill material were determined by soils mechanics tests. Model tests showed that transport and deposit of backfill material depend on the flow of slurry in the mine cavity. Roof falls which block or partially block corridors affect the radial flow and deposit patterns of backfill material.
(*h*) **Hydraulic Model Studies For Backfilling Mine Cavities,** E. J. Carlson, *Rept. REC-ERC 73-19*.

327-09390-220-00

CONTROL OF TURBIDITY OF CONSTRUCTION SITES

(*d*) Experimental; applied research.
(*e*) A study team was assembled to review current methods and techniques currently used for control of turbidity at construction sites. Research projects will be conducted in areas related to turbidity control where information is lacking.
(*g*) Ongoing research and factual information concerning turbidity and presently used methods of measurement and control of turbidity were assembled. A report is being prepared which will be made available to planners, designers, construction engineers, and other field construction personnel.
(*h*) Report in preparation.

327-09391-840-00

FLOW INTO INTERRUPTER DRAINS ON SLOPING LAND NOT INSTALLED PERPENDICULAR TO THE WATER TABLE GRADIENT

(*d*) Experimental; applied research.
(*e*) Field experience has shown that agricultural drains installed on an angle not perpendicular to the water table gradient are not effective when installed according to criteria for drains on level land. A 60-foot long, 2-foot wide, 2-1/2 foot-deep sand tank whose slope can be adjusted up to 12 percent will be used to determine adjustments in drain spacing that are necessary.
(*g*) The 60-foot long sand tank is in place and operating and preliminary tests have been made.

327-09392-350-00

OAHE FLAP-GATE

(*d*) Experimental; for design.
(*e*) Study was performed on a 1:12 model of a canal headworks which will be supplied by flow from the Oahe Pumping Plant located nearly 200 feet below the canal. The flap-gate concept was considered applicable in order to prevent backflow and draining of a long reach of the canal back through the head structure in the event of pump failure or line rupture. Opening and closing characteristics of the flap-gate were observed for a gate with a vertical axis, and for a gate with axis slightly tipped from vertical so as to be self-closing. The mass of water moving with the gate at time of closure was observed through dye injection methods.
(*f*) Completed.
(*g*) No difficulties were encountered during opening whether the canal was full or empty. Only a slight head differential was needed to move the gate. Rapid closures (large upstream line rupture) produced extremely heavy impulsive loads on the gate frame. Dye was injected from a manifold located perpendicular to the canal centerline as backflow began in the canal. Time sequence photos were made of the dye movement as the gate was closing. A zone of no upstream dye movement was observed in the flow as the gate slammed shut. The zone encompassed a sizable volume of water which greatly increased the loading on the gate and frame.
(*h*) Internal memorandum. (No formal publication available.)

327-09393-350-00

HYDRAULIC MODEL STUDIES OF PALMETTO BEND DAM SPILLWAY

(*d*) Experimental; for design.
(*e*) Hydraulic model studies aided in the design of the inlet channel to the spillway, the stilling basin, and the channel downstream from the spillway.
(*g*) Tests with a 1:100 scale overall model resulted in verification and slight changes to the initial design. The inlet channel was widened and a bend of the inlet channel placed further upstream. To improve flow entering the left side of the spillway a dike was placed upstream from the dam along the left side of the inlet channel. Length of the stilling basin was reduced by 30 feet and elevation of the floor raised 5 feet. Also it was found beneficial to add floor blocks and a dentated end sill to the stilling basin. Water flowed from the stilling basin onto a flood plain. Embankments were placed on each side of the stilling basin downstream for a 400-foot distance to channelize water leaving the spillway. The embankments prevented excessive circulation eddies near each end of the stilling basin. Because of the low Froude number stilling basin a 1:30 scale sectional model was used to finalize the design of the floor blocks and dentated end sill.

327-09394-840-00

DRAIN ENVELOPE STUDIES

(*d*) Applied research.
(*e*) Hydraulic flow tests of sections of corrugated plastic drain tubing will be made with gravel envelopes designed for irrigation drains. Measurements of discharge and head loss will be made and results compared with electric analog tests and design criteria.

U. S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, WATER RESOURCES DIVISION, 12201 Sunrise Valley Drive, Reston, Va. 22092. J. S. Cragwall, Jr., Chief Hydrologist.

328-0368W-200-00

TURBULENCE IN OPEN CHANNEL FLOW

(*c*) R. S. McQuivey.
(*e*) See Water Resources Research Catalog 9, 2.0641.

328-0369W-220-00

TRANSPORT PROCESSES IN ALLUVIAL CHANNELS

(*c*) C. F. Nordin.
(*e*) See Water Resources Research Catalog 9, 2.0336.

328-0370W-860-00

OXYGEN CYCLE IN STREAMS, LAKES, AND ESTUARIES

(*c*) R. E. Rathbun.
(*e*) See Water Resources Research Catalog 9, 2.0642.

328-0371W-300-00

NUMERICAL SIMULATION OF HYDRODYNAMIC PROCESSES IN RIVERS, ESTUARIES, AND EMBAYMENTS

(*c*) R. A. Baltzer.
(*e*) See Water Resources Research Catalog 9, 2.0956.

328-0372W-090-00

HYDRODYNAMIC STUDY ON THE TRANSPORT OF THERMAL, PHYSICAL, AND CHEMICAL CONSTITUENTS IN TURBULENT SURFACE WATER

(*c*) N. Yotsukura.
(*e*) See Water Resources Research Catalog 9, 2.0965.

328-0373W-220-00

SEDIMENT MOVEMENT AND HILLSLOPE MORPHOLOGY IN THE CENTRAL APPALACHIAN REGION

(*c*) G. P. Williams.
(*e*) See Water Resources Research Catalog 9, 2.0966.

328-0374W-820-00

DENVER MULTIPHASE FLOW

(*c*) E. P. Weeks.
(*e*) See Water Resources Research Catalog 9, 5.0234. See also 322-05841-820-00 in 1972 HRUSC.

328-0375W-810-00

PHYSICAL MODELING OF HYDROLOGIC SYSTEMS

(*c*) V. R. Schneider.
(*e*) See Water Resources Research Catalog 9, 6.0514.

328-0376W-200-00

LARGE SCALE OPEN CHANNEL EXPERIMENTS

(*c*) J. E. Bowie.
(*e*) See Water Resources Research Catalog 9, 6.0516.

328-0377W-740-00

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER

(*c*) V. C. Lai.
(*d*) See Water Resources Research Catalog 9, 6.0992. See also 332-08481-740-00 in 1972 HRUSC.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LANGLEY RESEARCH CENTER, Langley Station, Hampton, Va. 23665. Edgar M. Cortright, Director.

329-06654-540-00

WATER LANDING IMPACT OF SPACECRAFT AND AIRCRAFT

(*c*) Mr. Lloyd J. Fisher, Assistant Head, Dynamic Loads Branch, Mail Stop 230.
(*d*) Experimental and analytical applied research.
(*e*) Experimental landing impact investigations are made with scaled dynamic models. Various landing attitudes, speeds, and body configurations are simulated. Hydrodynamic force and pressure distribution data on either relatively rigid or partially elastic models are obtained for comparison with theory. Specific energy dissipation capabilities are determined for various impact systems and materials using structural testing procedures and drop model techniques.
(*f*) Stand-by basis.
(*g*) See (h).
(*h*) **Ditching Investigation of a 1/20-Scale Dynamic Model of the Space Shuttle Orbiter.** Contractor's report in preparation by Grumman Aerospace Corporation for NASA.

329-09395-420-00

WAVE REFRACTION MODELING OF THE BALTIMORE CANYON CONTINENTAL SHELF REGION AND MODEL VERIFICATION WITH REMOTE SENSING DATA

(*c*) Mr. Charles H. Whitlock, Head, Data Analysis Section, Marine Environments Branch, Mail Stop 322.
(*d*) Theoretical and experimental applied research.
(*e*) A first-order wave refraction model for the mid-Atlantic continental shelf region between 37.5° and 40° N latitudes is being developed, and remote sensing data are being taken in the region to provide data for verifying the model. Ocean waves are monitored from the edge of the continental shelf until they reach the shoreline to evaluate how the waves are modified by continental shelf bathymetry. This particular region was selected because it

fits as a subgrid to a planned National Weather Service ocean wave forecasting system and can be used for coastal wave experiment under the planned SEASAT satellite.

(*h*) **Random-Access Technique for Modular Bathymetry Data Storage in a Continental-Shelf Wave-Refraction Program,** L. R. Poole, *NASA TM X-3018*, July 1974.

329-09396-710-00

REMOTE SENSING OF COASTAL WATERS

(*b*) Joint Langley and Old Dominion University Project.
(*c*) Mr. Charles H. Whitlock, Head, Data Analysis Section, Marine Environments Branch, Mail Stop 322.
(*d*) Experimental, field investigation; applied research.
(*e*) Major effort has been to monitor suspended sediment (as a natural water tracer) and chlorophyll (as an indicator of water quality). Analysis techniques have been developed for measuring pollutants in water. Future efforts will be directed at automatic analysis of remotely sensed data, through the development of spectral signatures of pollutants, for monitoring water quality in the Coastal Zones.
(*h*) **Correlation of ERTS Multispectral Imagery with Suspended Matter and Chlorophyll in Lower Chesapeake Bay,** D. E. Bowker, P. Flerscher, T. A. Gosnik, W. J. Hanna, J. Ludwick, *NASA SP-327*, Mar. 1973.
Transmissometry and Suspended Matter in Lower Chesapeake Bay. Correlation with ERTS Multispectral Imagery, D. E. Bowker, P. Flerscher, T. A. Gosnik, W. J. Hanna, J. Ludwick, *Amer. Soc. Photogrammetry, Proc. Fall Convention*, Oct. 1973.

329-09397-860-00

THREE-DIMENSIONAL NUMERICAL WATER QUALITY MODEL FOR CONTINENTAL SHELF APPLICATION

(*b*) Joint Langley and University of Rhode Island Project.
(*c*) Mr. John T. Suttles, Head, Applied Environmental Modeling Section, Analytical Studies Branch, Mail Stop 324.
(*d*) Numerical, applied research.
(*e*) An alternating-direction implicit finite difference computational scheme is being used to develop a numerical model of the three-dimensional, time dependent continental shelf mass transport equation for water quality parameters. The model is being verified using one-, two-, and three-dimensional analytical solutions and by predicting the distribution of coliform concentration in the tidal portion of the Providence River. The verified model will then be employed to study the optimum location of a sewage outfall for New Shoreham in Block Island Sound.
(*h*) **Derivation of a Three-Dimensional Numerical Water Quality Model for Estuary and Continental Shelf Applications,** M. L. Spaulding, *NASA TM X-71930*, 1974.

329-09398-870-00

NUMERICAL-ANALYTICAL POLLUTION TRANSPORT MODEL FOR ESTIMATING ENVIRONMENTAL PARAMETERS FROM REMOTE SENSING DATA

(*c*) Mr. John T. Suttles, Head, Applied Environmental Modeling Section, Analytical Studies Branch, Mail Stop 324.
(*d*) Theoretical, applied research.
(*e*) The mass diffusion equation is being solved by using a numerical quadrature formulation of the advection transport effects and an analytical formulation of the diffusion transport effects. The resulting solution is being used to develop simplified models of the pollution dispersion from point and area sources in uniform flows with and without shear. The models will be used to study techniques for estimating environmental parameters from remote sensing data. Parameters included are diffusion coefficients, velocity vectors, velocity gradients and pollutant source strength and location.
(*h*) **An Integrated Approach to the Study of Pollution Transport and Waves in the Coastal Zone – Part II – Modeling,** G. R. Young, C. H. Whitlock, T. H. Rees, J. T. Suttles, R. E. Turner, presented *IEEE Intl. Conf. Engrg. in the Ocean Environment*, Halifax, Nova Scotia, Canada, Aug. 21-23, 1974.

329-09399-450-00

CONTINENTAL SHELF CIRCULATION MODEL DEVELOPMENT

(*c*) Mr. John T. Suttles, Head, Applied Environmental Modeling Section, Analytical studies Branch, Mail Stop 324.
(*d*) Numerical, applied research.
(*e*) A model of the circulation in a continental shelf region is being developed based on using a primitive variable formulation and numerically solving the conservation equations for mass, momentum, internal energy and salt. The hydrostatic and Boussinesq approximations are made and turbulent transfer coefficients are assumed. An empirical equation of state is used to obtain density from salinity, temperature, and pressure. The equations are solved in a finite difference form using an explicit, leap-frog technique. Methods of treating open boundaries are being studied and parametric studies will be performed to determine the effects of wind stress, bottom topography, stratification, and run-off.
(*g*) A "rigid-lid" approximation has been developed to filter external gravity waves. This has produced a significant increase in the time step of the computations.
(*h*) **An Integrated Approach to the Study of Pollution Transport and Waves in the Coastal Zone – Part II – Modeling,** G. R. Young, C. H. Whitlock, T. H. Rees, J. T. Suttles, R. E. Turner, presented *IEEE Intl. Conf. Engrg. in the Ocean Environment*, Halifax, Nova Scotia, Canada, Aug. 21-23, 1974.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER, Cleveland, Ohio 44135. Warner L. Stewart, Director of Aeronautics.

331-06344-620-00

HYDRODYNAMIC JOURNAL BEARING STABILITY TESTS IN WATER AT ZERO LOAD

(*c*) William J. Anderson, MS 23-2, Chief, Bearings and Mechanical Power Transfer Branch, Fluid System Components Division.
(*d*) Experimental and theoretical applied research.
(*e*) Investigations of the stability characteristics of tilting pad, herringbone, lobed and stepped journal bearing configurations were carried out. Analyses of lobed and stepped bearings were made and experiments were conducted with all of these bearing types in water, and some in MIL-L-7808G oil, at high speeds and zero loads.
(*g*) Stability experiments have been conducted in water at zero applied load and speeds to 12,000 rpm. A plain bearing run with a three-tilted-lobe journal was more stable than a three-centrally-lobed journal. The incorporation of axial grooves in a tilted-lobe journal generally enhances its stability. The tilted-lobe journals mated with plain bearings were unique in that, in some tests, the bearings could be run to a shaft speed twice the shaft speed at which initial fractional frequency whirl occurred before any sign of bearing distress was observed. From this study, thus far, five fixed-geometry bearings considered can be generally rated in order of diminishing stability as follows: (1) three-tilted lobe bearing (offset factor of 1.0), (2) herringbone-groove bearing, (3) one-segment, three-pad, shrouded Rayleigh-step bearing, (4) three-tilted lobe journal with grooves (offset factor of 1.0) mated with a plain bearing, and (5) three-centrally-lobed bearing with grooves (offset factor of 0.5).
Further water bearing stability studies have been conducted on journal bearings with 3, 5, and 7 tilted lobes and length to diameter ratios ranging from 0.2 to 1.0. They were tested in water and MIL-L-7808G oil at 294k (70°F) at speeds to 5,400 rpm and zero load. Stability was not appreciably affected by number of lobes and decreased with a decrease in length to diameter ratio. This work is covered in a TN which will be published in 1975.

(*h*) **Stability of Water-Lubricated Three-Lobe Journals Mated With Plain Bearings at Zero Load,** F. T. Schuller, *NASA TN D-6796*, 1972.
Experiments on the Stability of Various Water-Lubricated Fixed Geometry Hydrodynamic Journal Bearings at Zero Load, F. T. Schuller, *NASA TM X-68014*, 1972.
Design of Various Fixed-Geometry Water Lubricated Hydrodynamic Journal Bearings for Maximum Stability, F. T. Schuller, *NASA SP-333*, 1973.

331-07040-630-00

COMPENDIUM ON THE DESIGN OF TURBOPUMPS AND RELATED MACHINERY

(*c*) Cavour H. Hauser, MS 5-9, Head, Single Stage Compressor Section, Fluid System Components Division.
(*d*) Exposition of theoretical and applied research.
(*e*) Compile pertinent information on turbopumps developed by NASA, the various contract research and development programs, and in-house research. This information will be correlated and considered in proper perspective to provide a coherent presentation of the important principles of turbomachinery design. The Compendium will be published as a NASA Special Publication.
(*g*) Drafts of all seven chapters of the Compendium have been submitted. These are being edited and prepared for publication.

331-09400-110-00

LIQUEFIED-GAS TEMPERATURE MEASUREMENT

(*c*) Isidore Warshawsky, Technical Consultant, Instrument Development and Applications Office.
(*d*) Experimental and theoretical applied research.
(*e*) For measurements in pipe lines and storage vessels, installation practices are recommended that will minimize heat-conduction errors and reduce time lag. Techniques of time lag definition and experimental time constant determination are developed.
(*f*) Completed.
(*g*) Analysis, computation formulas, and experimental techniques are presented in *NASA TM X-68251*, *Paper 73-551 in Proc. of ISA Intl. Conf.*, Houston, Tex., Oct. 15, 1973, *ISA Transactions* **13**, 4, 1974.

331-09401-630-00

HYDRAULIC TURBINE TIP CLEARANCE STUDY

(*c*) Harold E. Rohlik, Chief, Turbodrive Branch.
(*d*) Applied research.
(*e*) Three blade tip configurations are being studied with clearances ranging from 2.5 to 7.5 percent of blade height. The test turbine consists of the first two states of the six stage axial flow turbine designed to drive the low-pressure oxygen pump of the Space Shuttle Main Engine. The tip configurations are conventional unshrouded, shrouded, and unshrouded with the running clearance recessed in the end walls.
(*f*) The tests have been completed. Data analysis and reporting are in progress.
(*g*) The shrouded blading was one to three points more efficient than the unshrouded. The decrease in efficiency with increasing clearance was nearly the same for all three kinds of tip clearance geometry.

331-09402-110-00

TWO-PHASE CHOKED FLOW OF SUBCOOLED LIQUID CRYOGENS

(*c*) Robert J. Simoneau, Aerospace Research Engineer.
(*d*) Experimental and analytical applied research.
(*e*) Measurement and analyses of flow rate and pressure data were undertaken for liquid cryogens discharging through various flow passages. The flow was always two-phase and choked. Initial conditions were always single-phase subcooled liquid and ranged from below to above thermodynamic critical conditions. Fluids included nitrogen, oxygen, methane and hydrogen. The work is directed toward the safe storage, handling and transfer of pressurized liquid cryogens.
(*g*) The main result is a wide variety of two-phase choked flow data covering several geometries, several fluids and extensive range of operating conditions. The data are all compared to equilibrium and non-equilibrium analyses which appear in the literature. The results show that the flow rate data of all the different fluids can be reduced to a normalized set by the low of corresponding states.
(*h*) **Two-Phase Critical Discharge of High Pressure Liquid Nitrogen,** R. J. Simoneau, R. E. Henry, R. C. Hendricks, R. Watterson, *Proc. 13th Intl. Congr. Refrigeration*, Washington, D. C., Aug. 1971.
Choked Flow of Fluid Nitrogen with Emphasis on the Thermodynamic Critical Region, R. C. Hendricks, R. J. Simoneau, R. C. Ehlers, *Advances in Cryogenic Engrg.* **18,** pp. 150-161, Plenum Press, N. Y., 1973.
Application of the Principle of Corresponding States to Two-Phase Choked Flow, R. C. Hendricks, R. J. Simoneau, presented 74th Natl. AIChE Mtg., New Orleans, La., (*NASA TMX-68193*), Mar. 1973.
A Visual Study of Radial Inward Choked Flow of Liquid Nitrogen, R. C. Hendricks, R. J. Simoneau, Y. Y. Hsu, *NASA TMX-68283*, presented *1973 Cryogenic Engrg. Conf.*, Atlanta, Ga., Aug. 1973 (to be published in *Advances in Cryogenic Engrg.*).
Two-Phase Choked Flow of Subcooled Nitrogen Through a Slit, R. J. Simoneau, *10th Southeastern Sem. Thermal Sciences*, New Orleans, La., pp. 225-238, Apr. 1974 (Ed. R. G. Watts and H. H. Sogin).

331-09403-540-00

LIQUID JET IMPINGEMENT ON SOLID SURFACES UNDER REDUCED GRAVITY CONDITIONS

(*c*) Thomas L. Labus, Aerospace Engineer.
(*d*) Numerical, experimental, applied research; Doctoral thesis.
(*e*) An inviscid model was chosen to describe the flow field of an axisymmetric liquid jet impinging normally to a circular disc under reduced gravity conditions. Numerical solutions to this free-boundary problem are being obtained for a number of discrete cases including those in which surface tension effects are significant. This study has applications to a fundamental understanding of liquid jet delivery, liquid transfer, baffle liquid interactions and fire extinguishment.
(*f*) Reduced-gravity experiments completed. Analysis including surface tension effects continuing. Normal gravity and heat transfer experiments are planned.
(*g*) For flows not significantly affected by viscous forces, as determined via an order of magnitude analysis, three distinct flow patterns were experimentally observed. These flow regions were defined as inertial, transition and capillary dominated and were defined by the system Weber number and the ratio of the jet to the disc radius.

331-09404-610-00

DESIGN OF FAST-RESPONSE ELECTROHYDRAULIC SERVOS FOR PROPULSION SYSTEM DYNAMICS AND CONTROLS RESEARCH INVESTIGATION

(*c*) Fred Teren, Head, System Dynamics Section, MS 100-1.
(*d*) Experimental; design and development.
(*e*) Design and test fast response electrohydraulic servos that utilize special design techniques for achieving fast response while retaining durability and mechanical integrity. Earlier work that led to this project dealt with performance optimization of electrohydraulic servo systems. This made it possible to design the fast response servos in an orderly consistent fashion with accurately predictable dynamic response capabilities. This work is continuing with design of a fast response pneumatic throttling valve that uses a electromagnetic shaker type of driver for the servo valve.

(*g*) Several recently designed servo systems have dynamic performance capabilities very close to predicted values and exhibit durability to tolerate extended use at high frequencies.

(*h*) **Improved Design of a High-Response Slotted-Plate Overboard Bypass Valve for Supersonic Inlets,** J. A. Webb, Jr., O. Mehmed, K. W. Hiller, *NASA TMX-2812*, June 1973.
Determination and Evaluation of Performance Limit Criteria of Fast-Response Electrohydraulic Servo Systems, J. R. Zeller, J. A. Webb, Jr., *NASA TMX-2736*, Mar. 1973.

UNITED STATES NAVAL ACADEMY, DEPARTMENT OF THE NAVY, Division of Engineering and Weapons, Annapolis, Md. 21402. Captain A. L. Jenks, USN, Division Director.

332-07046-720-22

THE DESIGN OF A HIGH PERFORMANCE TOWING TANK

(*b*) Naval Sea Systems Command.
(*c*) Dr. Bruce Johnson, Project Manager, Hydromechanics Laboratory.
(*d*) Design of a new facility.
(*e*) A 380 foot by 26 foot by 16 foot towing tank capable of speeds up to 50 feet per second is part of the new Rickover Hall Engineering Complex at the Naval Academy. The tank will support education and research in Naval Architecture, Ocean Engineering and Oceanography, as well as research in flow induced noise and computer generated irregular waves.
(*g*) The basin and carriages have been completed and a contract has been let for a large servo-hydraulic dual flap wavemaker. The wavemaker will be able to generate precisely controlled irregular waves under computer control.
(*h*) **A Proposal for an Irregular Wave Spectrum for Ship Model Testing,** B. Johnson, *Proc. 17th Amer. Towing Tank Conf.*, Calif. Inst. Tech., June 1974.

332-08494-420-20

TIME-DEPENDENT SHEAR STRESS BENEATH A SHOALING WAVE

(*b*) Office of Naval Research.
(*c*) Ensign J. W. Fisher, Dr. Bruce Johnson, Dr. Michael McCormick.
(*d*) Experimental.
(*e*) An experimental study of the time-dependent characteristics in shoaling waves using hot-film anemometers and a real time analysis computer system. The fluctuating shear stress was measured using flush-mounted hot-film sensors.
(*g*) Completed.
(*h*) **Time-Dependent Shear Stress Beneath a Shoaling Wave,** *Proc. Intl. Symp. Ocean Wave Measurement and Analysis*, ASCE/New Orleans, La., Sept. 9-11, 1974.

332-08495-130-22

COMPUTER STUDIES ON THE EVOLUTION OF WATER VAPOR CLUSTERS

(*b*) Naval Air Systems Command.
(*c*) Professor A. A. Pouring, Aerospace Engineering Department.
(*d*) Theoretical; basic research.
(*e*) In order to verify a new kinetic theory of cluster formation on condensation, theoretical and numerical techniques have been developed to calculate equilibrium conditions and subsequent non-equilibrium solutions applicable to some atmospheric conditions and rapid expansions in supersonic nozzles.
(*f*) Completed.
(*g*) The course of condensation in a supersonic expansion has been successfully calculated for water vapor in air. New insight into the non-equilibrium dynamics of collapse of a metastable phase has been gained from calculations on a collision by collision basis. It is shown that classical equilibrium concepts of nucleation have little if any significance for condensation in a rapid expansion.
(*h*) **The Kinetics of Evolution of Water Vapor Clusters in Air,** *EW Rept. 3-74*, May 1974.

332-09405-030-15

HELIUM BUBBLE SURVEY OF AN OPENING PARACHUTE FLOWFIELD

(*b*) U. S. Army Airdrop Engineering Laboratory.
(*c*) Asst. Professor P. C. Klimas or Professor D. F. Rogers, Aerospace Engineering Department.
(*d*) Experimental; applied research.
(*e*) Neutrally buoyant, highly reflective and durable helium filled soap bubbles are inserted into the airstream passing an opening parachute. With the bubble-time histories being recorded by two orthogonally located high speed motion picture cameras, the information is processed via a unique data handling and reduction scheme to provide a quantitative description of the kinematics of the flow about the unsteadily operating parachute canopy.

332-09406-060-00

MATHEMATICAL MODEL OF A HEAT SOURCE MOVING IN A STRATIFIED FLUID

(*c*) Professor R. A. Granger, Mechanical Engineering Department.
(*d*) Theoretical; basic research.
(*e*) Flow is considered steady and potential. Use of an asymptotic power series in powers of thermal diffusivity results in a set of third-order nonlinear partial differential equations. Zeroth-order set is solved in closed analytic form by use of similarity transformation.
(*f*) Completed.
(*g*) The velocity field for the zeroth-order solution is independent of the effect of thermal buoyancy. The thermal buoyancy is a first-order effect and can be found by solving first-order set of nonlinear partial differential equations.
(*h*) Presented *27th Ann. Mtg. Amer. Phys. Soc., Fluid Dyn. Div.*, Calif. Inst. of Tech., Nov. 1974, *U. S. Naval Acad. Engrg. Rept. EW 13-74*.

332-09407-480-20

A LABORATORY SIMULATION OF WEAK STRENGTH TORNADOS

(*b*) Office of Naval Research.
(*c*) Professor R. A. Granger, Mechanical Engineering Department.
(*d*) Experimental; basic research.
(*e*) Devise a laboratory facility to model the macroscopic characteristics of tornados.
(*f*) Completed.
(*g*) Two types of vortices were found to coexist. Analysis of carbon dioxide gas and helium bubbles disclosed downward motion along axes of both types of vortices, and convergent upward flow for the primary vortex. As circulation decreased, the vortex core thickened, and a critical core diameter exists where the vortex became unstable. The laboratory used the concept of a sink, but the physical model requires a source. As the vortex core length increased, the vortex stretched and the core narrowed, with the vorticity increasing.
(*h*) Presented *27th Ann. Mtg., Amer. Phys. Soc., Fluid Dyn. Div.*, Calif. Inst. of Tech., Nov. 1974, *U. S.. Naval Academy Engrg. Rept. EW-24-74*.

332-09408-420-48

WAVE-ENERGY CONVERSION BUOY

(*b*) U. S. Coast Guard.
(*c*) Professor Michael McCormick.
(*d*) Theoretical and experimental.

(e) A theory has been developed to analyze the ideal conversion of ocean wave energy to electrical energy by a pneumatic-type wave-energy conversion buoy. A tenth-scale model has been studied in a wave tank so as to verify the theory.
(g) The agreement between the theoretical and experimental results is excellent.
(h) **An Analysis of a Wave-Energy Conversion Buoy,** M. E. McCormick, *J. Hydronautics (AIAA)* 8, 3, pp. 77-82, July 1974.
A Parametric Study of a Wave-Energy Conversion Buoy, *Offshore Technol. Conf., Paper 2125*, Houston, May 1974.

332-09409-420-22

STUDY OF A STATIONARY WAVE-ENERGY CONVERTER

(b) U. S. Navy.
(c) Professor Michael E. McCormick.
(d) Theoretical and experimental.
(e) A theory designed to predict the wave-energy conversion by a stationary pneumatic wave-energy converter has been developed. Experiments are presently being conducted on a tenth-scale model to verify the theoretical results.
(g) The theory predicts an average power conversion of greater than 20 kw in a three-foot sea having periods greater than 3.5 seconds. The experiment is in progress.
(h) **An Analysis of a Stationary Pneumatic Wave-Energy Converter,** M. E. McCormick, *ASME Winter Ann. Mtg.*, N.Y., Oct. 1974. *Paper 74-WA/Oct-2.*
A Pneumatic Wave-Energy Converter for Offshore Structures, M. E. McCormick, R. Holt, C. Bosworth, *Offshore Technol. Conf., Paper 2259*, Houston, May 1974.

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CIVIL ENGINEERING LABORATORY, NAVAL CONSTRUCTION BATTALION CENTER, DEPARTMENT OF THE NAVY, Port Hueneme, Calif. 93043. Technical Director, Code L03.

333-08498-430-22

TRANSPORTABLE BREAKWATERS

(b) Naval Facilities Engineering Command, Director of Navy Laboratories.
(c) Director, Amphibious and Harbor Division, Code L55.
(d) Experimental, theoretical, and field investigation; applied research, development.
(e) Survey of concepts for a wave barrier, to identify those having potential application in a "transportable" (or "portable") breakwater; emphasis on wave transmission properties.
(f) Completed.
(g) Some 100 existing concepts for wave barriers were assembled into an outline classification of transportable breakwaters based on type (form) of structure; sketches (cross sections) and concise summaries of wave transmission data were included. A closer review of flexible floating breakwaters was made in a later study, which included an analysis of wave damping associated with energy dissipation in a viscoelastic blanket.
(h) **Transportable Breakwaters – A Survey of Concepts,** D. B. Jones, Civil Engrg. Lab., *Tech. Rept. No. R-727*, 70 pages, May 1971 (available NTIS, Operations Division, Springfield, Va. 22151).
Flexible Breakwaters, D. B. Jones, Civil Engrg. Lab., *Tech. Note 1351*, 60 pages, Sept. 1974 (available NTIS, Operations Division, Springfield, Va. 22151).

333-09410-430-22

DYNAMICS OF FLEXIBLE CABLES IN THE OCEAN

(b) Naval Facilities Engineering Command.
(c) Dallas Meggitt, Lieutenant Brent Taylor, Harry Zwibel, Ocean Structures Division, Code L44.
(d) Theoretical, laboratory, field studies; applied research.
(e) Develop the capability to predict and control dynamic responses of cable/buoy arrays in the deep ocean. The research has been divided into large-displacement low-frequency dynamics, and small-amplitude high-frequency dynamics (strumming). Mathematical models are being developed and tested through laboratory experiments. The models will also eventually be validated with field experiments.

333-09411-220-22

CONTROL OF SEDIMENTATION IN NAVY HARBORS

(b) Naval Facilities Engineering Command.
(c) Lt. Brent Taylor, Ocean Structures Division, Code L44.
(d) Applied experimental research.
(e) Several conceptual alternatives to conventional dredging are being investigated through laboratory and field experiments, to obtain environmentally cleaner and less expensive techniques/equipment to control sedimentation in Navy harbors.
(g) This multi-year project began in FY75.

333-09412-600-22

THE COANDA-EFFECT OIL-WATER SEPARATOR: A FEASIBILITY STUDY

(b) Director of Navy Laboratories.
(c) Mr. D. Pal, Mechanical Systems Division, Code L63.
(d) Experimental, theoretical investigation; applied research, development.
(e) Project is a feasibility study of using the fluid dynamic phenomenon called the "Coanda Effect or Wall Attachment" as a means to separate free oil from oil-water mixtures.
(g) Feasibility tests indicate the "Coanda Effect" oil-water separator can remove about one-half of the oil from an oil-water mixture originally containing six percent oil. The extracted oil contained five percent water. To improve the separator efficiency staging of individual separators is necessary. To improve the quality of extracted oil, an automated oil extraction rate controlling system is required. Improvements to the separator effectiveness can be accomplished by modifying the velocity distribution of the mixture jet. Conceptual designs have been formulated.

333-09413-600-22

APPLICATION OF FLUIDIC CONCEPTS TO HYDRAULIC CONTROL SYSTEMS

(b) Director of Navy Laboratories.
(c) E. R. Durlak, Mechanical Systems Division, Code L63.
(d) Experimental, theoretical investigation; applied research, development.
(e) Determine the feasibility of using fluidic concepts to develop a fluidic control unit that will detect and correct angular variations in position such as those experienced by a bulldozer blade.
(g) A hydraulic proximity sensor was developed and tested. This sensor represents a key component of the control unit to detect and correct angular variations in position. The successful tests of the hydraulic proximity sensor indicate that it is possible to design hydraulic fluidic components from existing pneumatic components by using a constant value of the Reynolds number as the scaling factor.
(h) **Application of Fluidic Concepts to Hydraulic Control Systems,** R. H. Fashbaugh, E. R. Durlak, *Civil Engrg. Lab, Tech. Note N-1255*, Dec. 1972.
Application of Fluidic Concepts to Hydraulic Control Systems, R. H. Fashbaugh, E. R. Durlak, Civil Engrg. Lab., *Tech. Note N-1349*, July 1974.

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U. S. NAVAL OCEANOGRAPHIC OFFICE, Washington, D. C. 20390. Boyd E. Olson, Scientific and Technical Director.

334-06454-420-00

WAVE FORECASTING RESEARCH

(*c*) Mr. John J. Schule, Jr., Director, Science and Engineering Directorate.
(*d*) Applied research involving field experiments with wind-generated ocean waves.
(*e*) Development of automated wave prediction techniques on an oceanwide basis including the North Atlantic Ocean, North Pacific Ocean, South China Sea, and Mediterranean Sea; observations of fetch-limited wave spectra with an airborne laser, shipboard observations of wave spectra with a bow-mounted wave sensor. Development of hindcast directional wave spectra for North Atlantic and North Pacific in support of Space Shuttle and SKYLAB programs. Calculation of severe storm statistics for offshore structures on East Coast. Correlation of ocean surface roughness with scattering of acoustic waves.
(*g*) An operational wave prediction model has been developed for most of the northern hemisphere.
(*h*) **Observations of Wave Spectra in the Caribbean Sea with an Airborne Laser,** P. S. DeLeonibus, R. J. Sheil, *NAVOCEANO TECH Note 6110-6-73*, 1973.
Equilibrium Range in Wave Spectra Observed at an Open-Ocean Tower, P. S. DeLeonibus, L. S. Simpson, M. G. Mattie, 1974.
An Operational North Pacific Wave Spectral Model, S. M. Lazanoff (NAVOCEANO), N. M. Stevenson (FNWC, Monterey, Calif.), *EOS, Trans., AGU* **56**, p. 1136, 1974 (abstract).

U. S. NAVAL POSTGRADUATE SCHOOL, Department of Mechanical Engineering, Monterey, Calif. 93940. Dr. R. H. Nunn, Department Chairman.

335-07056-600-14

A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF TURBULENT JETS IN BEAM-DEFLECTION AMPLIFIERS

(*b*) Army Research Office, Durham.
(*c*) T. Sarpkaya, Professor.
(*d*) Theoretical and experimental study of the velocity and turbulence distributions in the interaction region of the jets. Basic research for M.S. and Ph.D. theses.
(*e*) Study jet pinching, resultant jet deflection, noise sources and distribution, the effects of setback and control-port width and Reynolds number on the amplifier gain, and the modeling laws.
(*g*) The study of the velocity and turbulence profiles in the interaction and flow-establishment region of three jets of unequal velocities has shown that the increase of the strengths of control jets (higher normalized average control flow) results in the pinching of the power jet, in nonlinearity of the jet deflection, and in lower noise and sensitivity; the deflection of the jet does not materially affect the noise level at a given axial distance larger than 4w; the minimum noise level is in the order of 5 percent due to the contributions of the jet interaction and flow entrainment and could be considerably higher at normal operating conditions due to several other factors such as aspect ratio, receiver shape, cavity oscillations, etc.; the noise level remains relatively low and constant in the jet-establishment region and increases almost linearly in the fully-developed region; all components of turbulence are of the same order of magnitude and must be taken into consideration in the determination of the noise level; in the design and operation of a proportional amplifier, one must not use a center dump, must capture the noise-free region of the jet, place the receivers as close as possible to the pivoting point, and use as low control flows as practically possible to achieve a given jet deflection; and that the design of a proportional amplifier may be confidently based on the results of the free-streamline theory carried out as part of the present investigation.
(*h*) **On Mean Motion, Jet Turbulence, and Noise in Proportional Amplifiers,** T. Sarpkaya, *Proc. Intl. Fed. Automatic Controls* **2,** pp. 1-7, Sec. A, June 1971.
Jet Deflection, Noise, Etc., *Engineers Degree Thesis*, NPS, Sept. 1971.

335-07057-250-21

RESISTANCE TO THE FLOW OF DILUTE AQUEOUS POLYMER SOLUTIONS

(*b*) Naval Ship Research and Development Center.
(*c*) T. Sarpkaya, Professor.
(*d*) Theoretical and experimental study of the flow of second-order viscoelastic fluids and the lift and drag characteristics of hydrofoils immersed in dilute polymer (WSR-301) solutions. Ph.D. thesis.
(*e*) The effect of polymers on the lift and drag of hydrofoils is being studied through the use of a water tunnel.
(*g*) The flow of aqueous solutions of Polyox WSR-301, with concentrations to 1.0 to 200 wppm, about circular cylinders was investigated in the critical Reynolds number regime. The drag force, pressure distribution, separation angle, and the vortex shedding frequency were measured on cylinders with diameters 1/4 to 1-1/2 inch. Two distinct types of drag transition between the subcritical and supercritical regimes were observed. At high concentrations, the transition occurred at the same ambient velocity independent of the body diameter; and at low concentrations and/or in situ molecular weights, tripping from a subcritical to a supercritical flow occurred at a well-defined flow condition which was a function of the ambient velocity, cylinder size, and the turbulent friction-reducing effectiveness of the solution in pipe rheometer. In all cases, transition occurred earlier than that in the pure solvent and was accompanied by a strong secondary flow in the separation region and relatively large amplitude pressure oscillations over the entire cylinder.
(*h*) **Flow of Dilute Polymer Solutions About Circular Cylinders,** T. Sarpkaya, P. G. Rainey, *NPS-59SL1021A*, Feb. 1971.
Flow of Dilute Polymer Solutions About Bluff Bodies, T. Sarpkaya, *Proc. Canad. Cong. Appl. Mech.*, pp. 627-628, June 1971.

335-08499-530-21

FLOW OF DILUTE POLYMER SOLUTIONS ABOUT HYDROFOILS

(*b*) Naval Ship Research and Development Center.
(*c*) T. Sarpkaya, Professor.
(*d*) Theoretical and experimental determinations of the effect of polymer solutions on the lift and drag forces characteristic of hydrofoils.
(*e*) Hydrofoils are used for a wide variety of purposes such as propeller blades on boats, as sailboat keels, ship rudders, submarine and torpedo fins, lifting surfaces of hydrofoil boats, shroud ring stabilizers for missiles, rotor blades for water jet propulsion units, impeller blades in pumps, support struts, etc. These different applications have resulted in the development of a wide variety of hydrofoil forms and in an intensive search for the increase of lift primarily for the purpose of optimizing the lift and drag characteristics of the foil and the performance of the body to which it is attached. To this end, a series of measurements of the lift and drag forces acting on an uncambered, streamlined, fully-wetted hydrofoil (NACA-0024) immersed in homogeneous solutions of a high-molecular-weight additive (Polyox WSR-301) was carried out in a circulating water tunnel with a test section four inches wide and eight inches deep.
(*g*) The comparison of the results with those obtained using tap water as the working fluid has shown that the polymer additive has no measurable effect on the lift and drag of the hydrofoil within the range of concentrations used (1 to 200 wppm) and the Reynolds numbers attained (approx: 2 x 10^5).

(*h*) **Flow of Dilute Polymer Solutions About Circular Cylinders,** T. Sarpkaya, P. G. Rainey, *NPS-59SL1021A*, Feb. 1971.
Flow of Dilute Polymer Solutions About Bluff Bodies, P. G. Rainey, *Ph.D. Thesis*, NPS, Mar. 1971.

335-08500-600-22

EVALUATION OF FLUIDIC CONCEPTS FOR GUIDANCE AND CONTROL

(*b*) Naval Air Systems Command.
(*c*) T. Sarpkaya, Professor.
(*d*) Experimental, theoretical, Master's thesis.
(*e*) Evaluation of advance control concepts utilizing fluidic systems.
(*g*) It is as a consequence of these studies that a new pneumatic vortex angular rate sensor has been conceived, designed, tested, and analyzed. The porous coupling, used in all other vortex rate gyros, was replaced by a series of vanes and viscous coupling and a new pickoff system comprised of two spherical elements was introduced. The experimentally determined differential-pressure outputs compared favorably well with those predicted theoretically. Furthermore, the elimination of the porous coupling, the use of vanes and viscous coupling, and more importantly, the use of spherical pickoff elements have resulted in the increase of the sensor output, in the decrease of noise, in the elimination of the null-signal, and in the increase of the range of linearity of the sensor.
(*h*) **On a New Vortex Angular Rate Sensor,** T. Sarpkaya, *Proc. Intl. Federation of Automatic Controls* **2**, pp. 86-91, Sec. B, June 1971.
Of Fluid Mechanics and Fluidics and of Analysis and Physical Insight, presented *5th Cranfield Fluidics Conf.*, Uppsala, Sweden, June 1972.

335-08501-600-22

FLUERIC LOW-FREQUENCY NOISE ANALYSIS

(*b*) Naval Air Systems Command.
(*c*) T. Sarpkaya, Professor.
(*d*) Experimental, theoretical, Master's thesis.
(*e*) An investigation of the noise characteristics of flueric devices especially of the jet deflection type.
(*g*) It has been found that the smaller aspect ratios show a much greater variation in percentage of turbulence with low power-jet pressures; at higher pressures, the percentage turbulence is approximately constant with pressure changes, for all aspect ratios tested; and the peak percentage turbulence increases with increasing aspect ratio. The results have also shown that an improved signal-to-noise ratio is not obtained without paying a price; in this case, a reduction in gain. The data show that the pressure gain is almost insensitive to power jet pressure but varies with aspect ratio. In particular, the gain falls off rapidly below an aspect ratio of two. This is also the range in which the turbulence intensity becomes a function of power-jet pressure and assumes very small values at low pressures. Thus it is concluded that the most important design goal is the modification of the amplifier geometry to obtain reasonable gains at low aspect ratios and power-jet pressures while yielding a low noise coefficient. This aspect of the project will be further investigated.
(*h*) **On Mean Motion, Jet Turbulence, and Noise in Proportional Amplifiers,** T. Sarpkaya, *Proc. of the IFAC* **2**, pp. 1-7, Sec. A, June 1971.

335-08502-540-00

VORTEX BREAKDOWN ABOVE DELTA WINGS IN TRANSONIC FLOW

(*c*) T. Sarpkaya, Professor.
(*d*) Theoretical and experimental.
(*e*) Determine the effect of compressibility on vortex breakdown above delta-wings at high angles of attack in a transonic flow.
(*g*) A theoretical solution has been obtained for the transonic flow field where the phenomenon of vortex separation from the side-edges is approximated by introducing into the analytical flow field a ray of singularity possessing the vortex behavior. The strength and the location of the vortex sheet were determined by assuming (and justifying the assumptions) that the flow field around the edges is bounded and that the vortex system is dynamically free. In view of the scarcity of experimental results, it was decided to perform pressure and moment measurements as well as flow visualization experiments. The vortex cores were visualized by injection of smoke and photographing through a flash unit. The work is in progress and the results will be incorporated into a report.

335-08503-000-00

STABILITY OF HAGEN-POISEUILLE FLOW WITH SMALL SWIRL

(*c*) T. Sarpkaya, Professor.
(*d*) Theoretical.
(*e*) A theoretical investigation of this problem has been undertaken and has shown that very small amounts of swirl can render the flow unstable. In short, the theoretical context of the study is a global theory in which the linear limit gives sufficient conditions for instability, and the energy limit gives sufficient conditions for stability. Ordinarily these two limits do not coincide when one considers only small, non-spiraling disturbances.
(*g*) We show that, with small swirl, these two limits can coincide and that there is a stability limit (a relatively low Reynolds number) below which the flow becomes unstable. Thus the observed instabilities of laminar flow in pipes are consequences of initial swirl present in the flow and not a consequence of initial small disturbances.

335-08504-030-00

SUPERSONIC FLOW ABOUT AXISYMMETRIC BODIES AT LARGE ANGLES OF ATTACK

(*c*) T. Sarpkaya, Professor.
(*d*) Theoretical and experimental.
(*e*) The present theoretical and experimental work is aimed at filling the existing gap partly for the purpose of providing design information to aerospace industry and partly for the purpose of understanding the fluid dynamics of separated, unsteady, turbulent flows.
(*g*) The results so far obtained have revealed three rather interesting regions of flow: separation region, vortex growth region, and fully developed turbulent flow region in which there is no observable vortex shedding. The forces acting on the bodies are being measured for both the steady and unsteady motions of the body.

335-08505-550-22

AIR BREATHING PROPULSORS

(*b*) Naval Weapons Center, China Lake.
(*c*) R. H. Nunn, Assoc. Professor.
(*e*) Develop an analytical model to evaluate the effects of geometry control on external-ramp-inlet ramjet performace.
(*f*) Completed.
(*g*) An analytical model has been mechanized to predict the effect of inlet and/or nozzle area variations upon selected ramjet performance indicators.
(*h*) **Ramjet Area Control by Fluid Injection,** R. H. Nunn, *NPS-59NN71031B*, Mar. 1971.

335-08506-600-22

FLUID INTERACTION CONTROL TECHNIQUES

(*b*) Naval Air Systems Command.
(*c*) R. H. Nunn, Assoc. Professor.
(*d*) Theoretical, experimental, Master's thesis.
(*e*) Provide analytical backup and investigate experimentally engineering concepts in fluidic controls for tactical missiles.
(*f*) Completed.
(*g*) Several related areas have been studied, see (h) for detailed results.

(*h*) **A Review and Comparison of Tactical Missile Control Methods,** R. H. Nunn, *NPS-59NN 72121A*, Dec. 20, 1972.
Transverse Jets for Control of Missile Steering Thrustors, R. H. Nunn, *NPS-59NN72041A*, Apr. 10, 1972.
Jet Penetration at a Sonic Throat, R. H. Nunn, K. E. Frick, *J. Spacecraft* **10,** 12, pp. 19-820, 1973.

335-08507-030-22

FLOW STUDIES OF AXISYMMETRIC BODIES AT EXTREME ANGLES OF ATTACK

(*b*) Naval Weapons Center, China Lake.
(*c*) R. H. Nunn, Assoc. Professor.
(*d*) Theoretical, experimental, Ph.D. thesis.
(*e*) Identify, characterize and measure the flow field in the wake of an axisymmetric body at high angles of attack from 0 to 90°.
(*f*) Completed.
(*h*) **Flow Studies of Axisymmetric Bodies at Extreme Angles of Attack,** L. H. Smith, R. H. Nunn, *NPS-59NN720BZA*, Aug. 18, 1972.
Aerodynamic Characteristics of an Axisymmetric Body Undergoing a Uniform Pitching Motion, L. H. Smith, *Ph.D. Thesis, NPS*, Dec. 1974.

335-08508-870-00

OIL SET-UP DUE TO CURRENT

(*c*) C. J. Garrison, Asst. Professor.
(*d*) Theoretical.
(*e*) Analytically describe the processes by which current and oil set-up are coupled.

335-08509-420-00

WAVE FORCES ON A SUBMERGED CYLINDER

(*c*) C. J. Garrison, Asst. Professor.
(*d*) Theoretical and experimental.
(*e*) Analytical determination and experimental variation of wave forces upon deep and shallow bodies.
(*h*) **Interaction of Waves with Submerged Objects,** C. J. Garrison, V. Seetharama Rao, *J. Waterways, Harbors and Coastal Engrg. Div., Proc. ASCE* **97,** WW2, May 1971, p. 259-277.
Interaction of a Train of Regular Waves with a Rigid Submerged Ellipsoid, V. Seetharama Rao, C. J. Garrison, *Res. Rept. TAMU-SG-71-209*, May 1971.
Forces Exerted on a Submerged Oil Storage Tank by Surface Waves, C. J. Garrison, P. Y. Chow (submitted to *J. Waterways, Harbors and Coastal Engrg. Div., ASCE*); presented *Offshore Technology Conf.*, Apr. 1972.

335-08511-390-00

HYDRODYNAMIC LOADS INDUCED BY EARTHQUAKES

(*c*) C. J. Garrison, Asst. Professor.
(*d*) Theoretical.
(*e*) Analytically describe current transmission and arrival of hydrodynamic forces due to earthquakes.
(*h*) **Hydrodynamic Loads Induced by Earthquakes,** C. J. Garrison, presented *Offshore Technology Conf.*, Apr. 1972.

335-08512-690-00

PULSATING SUBSONIC FLOW IN A CONICAL NOZZLE

(*c*) T. M. Houlihan, Asst. Professor.
(*d*) Experimental, theoretical, Master's thesis.
(*e*) Phase and amplitude relations between pressure and velocity are analytically predicted and experimentally measured for subsonic compressible flow.
(*f*) Completed.
(*g*) Good agreement is found between the experimental measurements and the analytical predictions.
(*h*) **Pulsating Subsonic Flow in Convergent Nozzles,** T. M. Houlihan, Lt. E. J. Carlson, USN, presented at *NAAC Symp.*, White Oak, Md., May 1972.
An Experimental Investigation of Pulsating Subsonic Flow in a Conical Nozzle, E. J. Carlson, *NPS Master's Thesis*, Sept. 1971.

335-09414-700-00

LIQUID CRYSTAL THERMOGRAPHY

(*c*) T. E. Cooper, Associate Professor, Code 59 Cg.
(*d*) Basic experimental research (Master's theses) on the use of cholesteric liquid crystals as temperature sensors.
(*e*) Cholesteric liquid crystals are used as the surface temperature sensor on a heated cylinder placed in a crossflow of air. The liquid crystals produce a visual display of the surface temperature distribution and allow one to easily and quickly determine the variation of the Nusselt number with angular position.
(*g*) The liquid crystal thermographic technique provides an excellent means of obtaining both qualitative and quantitative heat transfer information on heated objects placed in forced convection environments. Using the technique it was possible to quickly determine the angular variation of the Nusselt number on a uniformly heated cylinder placed in a crossflow of air. The technique also allowed one to visually observe the effects of flow separation, the turbulent boundary layer, and the turbulent wake on the surface temperature of the cylinder. The technique is presently being used to investigate the last transfer characteristics of a uniformly heated cylinder placed near a flat surface that is aligned parallel to a flow of air.
(*h*) **Liquid Crystal Mapping of the Surface Temperature on a Heated Cylinder Placed in a Crossflow of Air,** R. J. Field, *NPS Master's Thesis*, Mar. 1974.
Experimental Investigation of Ground Effects on a Heated Cylinder in Crossflow, J. P. McComas, *NPS Master's Thesis*, Dec. 1974.
A Liquid Crystal Thermographic Study of a Heated Cylinder in Crossflow, T. E. Cooper, R. S. Field, J. F. Meyer, *NPS-59Cg741111*, Nov. 1974.

335-09415-540-22

DYNAMICS OF LIQUID PROPELLANT LOADING SYSTEMS

(*b*) Naval Sea Systems Command.
(*c*) R. H. Nunn, Associate Professor, Code 59Nn.
(*d*) Experimental and analytical, applied research, Master's thesis.
(*g*) Preliminary analytical model and laboratory simulation apparatus are completed.
(*h*) Documentation currently limited to informal progress reports to sponsor.

U. S. NAVAL POSTGRADUATE SCHOOL, Department of Oceanography, Monterey, Calif. 93940. Dr. D. F. Leipper, Department Chairman.

336-08519-450-20

SMALL SCALE INTERACTIONS IN THE UPPER OCEAN

(*b*) Office of Naval Research.
(*c*) Dr. Noel Boston, Dr. E. B. Thornton, Assoc. Professors.
(*d*) Theoretical, field and experimental research.
(*e*) Measurements of ocean waves, water particle velocities, temperature and conductivity fluctuations; acoustic amplitude fluctuations and acoustic phase modulations have been made and are being analysed.
(*g*) Spectra and correlation of parameters have been computed. Semi-empirical models under development. Wave-temperature fluctuation-temperature gradient model has been developed.
(*h*) **Separating Turbulent and Wave-Induced Velocity and Temperature Fluctuations,** E. B. Thornton, N. E. Boston, *Tech Rept. NPS 58TM74021*, Jan. 1974.
Water Particle Velocities Measured Under Ocean Waves, E. B. Thornton, R. F. Krapohl, *J. Geophys. Res.* **79,** 6, 1974.

Shallow Water Experiment Utilizing the STD Model 9006 at a Fixed Point, W. J. Frigge, *M.S. Thesis*, NPS, Mar. 1973.
Comparison of Measured and Calculated Sound Velocity Near the Sea Surface, J. Gossner, *M.S. Thesis*, NPS, Mar. 1973.
Small Scale Temperature Fluctuations Near the Sea Surface, M. A. N. Whittemore, *M.S. Thesis*, NPS, Mar. 1973.
A Study of the Effects of Internal Wave Induced Turbulence on Small Scale Temperature Structure in Shallow Water, J. C. Minard, *M.S. Thesis*, NPS, Sept. 1973.
Small Scale Interactions in the Near Surface Ocean, M. C. Haley, *M.S. Thesis*, NPS, Dec. 1973.
An Investigation of Surface and Internal Wave-Induced Turbulence in Shallow Water Thermal Microstructure, J. W. Powell, *M.S. Thesis*, NPS, Mar. 1974.
Measurement and Analysis of Temporal Variations of Salinity in Shallow Water, L. K. Kane, *M.S. Thesis*, NPS, Sept. 1974.
Acoustic Fluctuations Due to Shallow Water Thermal Microstructure, J. B. Hagen, *M.S. Thesis*, NPS, Sept. 1974.

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U. S. NAVAL POSTGRADUATE SCHOOL, Department of Physics and Chemistry, Monterey, Calif. 93940. Dr. K. E. Woehler, Department Chairman.

337-07060-250-00

DRAG COEFFICIENTS OF SPHERES IN DILUTE AQUEOUS SOLUTIONS OF HIGH POLYMERS

(*c*) Dr. J. V. Sanders, Assoc. Professor.
(*d*) Experimental, basic.
(*e*) The trajectories of spheres freely falling in water and in dilute aqueous solutions of drag-reducing polymers were determined from stereoscopic photographs and the measured terminal speeds used to determine the drag coefficients and Reynolds numbers. The size and density of the spheres were chosen to cover a Reynolds number range from 10 x 10^5 to 7 x 10^5.
(*g*) In both water and polymer solutions spheres attaining Reynolds numbers less than the critical value (2.2 x 10^5) display little scatter in the terminal speeds. The same is true for spheres attaining the highest Reynolds numbers studied. Spheres with Reynolds numbers immediately above the critical value frequently deviate from a straight trajectory and even when falling fairly straight, show a scatter in terminal speeds as great as 20 percent. The polymer did not alter the critical Reynolds number. For Reynolds numbers less than the critical value, polymer decreased the drag coefficients; for Reynolds numbers greater than 6 x 10^5, the polymer did not affect the drag coefficient; for intermediate Reynolds numbers, the polymer increased the drag coefficient.

337-09416-250-00

TURBULENCE STRUCTURE OF WAKES IN POLYMER SOLUTIONS

(*c*) Dr. J. V. Sanders, Associate Professor.
(*d*) Experimental analyses, basic research, Master's thesis.
(*e*) Investigate the influence of drag reducing polymers in aqueous solution on the turbulence structure of wakes behind bodies.
(*g*) A laser velocimeter system was designed and constructed. The system is used in the dual scatter, individual realization mode to measure longitudinal velocity components. The construction of a flow facility was begun.
(*h*) **A Laser Velocimeter to Study Turbulent Flow,** R. B. Yule, *Master Thesis*, NPS, Dec. 1974.

337-09417-510-00

ACOUSTIC SIGNATURES ACCOMPANYING WATER ENTRY

(*c*) Dr. J. V. Sanders, Assoc. Professor.
(*d*) Experimental, basic, Master's thesis.
(*e*) Solid metal spheres, simple missile-like shapes, and a bowling ball were dropped from varying heights below 4m into a water-filled anechoic tank and the resulting acoustic signatures were recorded and analyzed. In addition, the hydrodynamics of the drops were recorded on movie film for correlation with the acoustic signature.
(*f*) Completed.
(*g*) The oscillation of the air-filled cavity behind the bodies after impact was found to produce the most predominant aspect of the acoustic signature and the resultant frequency of these oscillations was dependent upon the impacting kinetic energy and shape of the body. Other signal characteristics investigated were total acoustic energy, peak acoustic pressure, and decay rate but correlation with the parameters of the bodies was not obvious.
(*h*) **Acoustic Signatures Accompanying Low-Velocity Water Entry,** *M.S. Thesis*, NPS, Dec. 1973 (DDC Cameron Station, Alexandria, Va. 22314).

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U. S. NAVAL RESEARCH LABORATORY, Washington, D. C. 20375. John T. Geary, CAPT, USN, Director.

338-07063-020-00

DIFFUSIVITY OF HEAT AND SALINITY IN WATER

(*c*) Dr. Allen H. Schooley, Code 8304, Building 208.
(*d*) Experimental exploratory applied research.
(*e*) Molecular and eddy diffusivity of temperature and salinity in water were measured with no turbulence and controlled amounts of increasing turbulence.
(*f*) Completed.
(*g*) The dissipation of turbulent power density (P) was found to be on the order of 10^7 larger than the power density (P′) consumed in changing the thickness ot the pycnocline. The experiments hint that P/P′ may be relatively constant over a range of turbulence.
(*h*) **Turbulent Diffusion of Temperature and Salinity: An Experimental Study,** A. H. Schooley, *8th Symp. Naval Hydrodynamics*, ONR, Cal. Tech., Aug. 1970. *Symp. Proc. ARC-179*, Office of Naval Research, Arlington, Va.

338-07064-460-00

VISCOUS FLOW IN THE AIR AND WATER WITHIN THE MOLECULAR SUBLAYERS AT THE NAVIFACE (SEA-AIR INTERFACE)

(*c*) Dr. Allen H. Schooley, Code 8304, Building 208.
(*d*) Phenomenological applied research.
(*e*) Heat balance at the sea surface is assumed to be dominated by molecular evaporation, and molecular heat conduction very near to the undulating naviface, plus a radiation balance term. The effective thickness of the molecular layers is dependent on the conditions of wind speed, phase position along the wave, air-sea temperatures, and cloud conditions. Laboratory wind-tunnel experiments are being used to help understand limited observations at sea.
(*g*) Some preliminary results are given under (h).
(*h*) **Diffusion Sublayer Thickness Over Wind Disturbed Water Surfaces,** A. H. Schooley, *J. Phys. Oceanog.* **1**, 3, p. 221, July 1971.
Whitecap Suppression by Cloud Shadows, A. H. Schooley, *J. Mar. Res.* **30**, 3, p. 315, Sept. 1972.
Wind-Swept Water Surface in Laboratory Cooled by Applying Heat, A. H. Schooley, *J. Mar. Res.* **31**, 1, p. 93, Jan. 1973.

338-07065-420-22

MICROWAVE SCATTERING FROM WIND WAVES

(*b*) Department of the Navy.
(*c*) Dr. John W. Wright, Code 8344.
(*d*) Basic experimental research on wind-generated water waves using microwave radars; basic theoretical research on mechanisms for the growth of water waves by the wind.

(*e*) Understand the short gravity-capillary part of the oceanic water wave system. Microwave radars are used to measure water wave speeds and amplitudes in laboratory wave tanks. Emphasis is placed on the response of the spectrum to external forces and other parts of the wave spectrum. Theory of wave-wave interactions and how the wind generates waves is conducted.

(*g*) The temporal growth of waves having wavelengths between 7 mm and 7 cm has been measured over a wide range of windspeeds. Effects of straining due to long water waves on the short gravity-capillary part of the wave spectrum have been studied both experimentally and theoretically; good agreement exists for wind speeds less than ten knots.

(*h*) **Fetch and Wind Speed Dependence of Doppler Spectra,** J. R. Duncan, W. C. Keller, J. W. Wright, *Radio Science* **9,** pp. 809-819, Oct. 1974.

The Effect of Capillarity and Resonant Interactions on the Second Order Doppler Spectrum of Radar Sea Echo, *J. Geophys. Res.* **79,** pp. 5031-5037, Nov. 20, 1974.

Microwave Doppler Backscatter Using a Focussed Parabola: A Versatile Wave Probe, T. R. Larson, J. W. Wright, *NRL Rept. 7850*, Dec. 1974.

338-07067-420-00

SEA SPECTRA ANALYSIS

(*c*) Denzil Stilwell, Jr., Code 5273.

(*d*) Field investigation of a novel technique of sea spectra measurement and basic research into the behavior of the sea surface.

(*e*) This project involves the processing of photographs of the sea surface taken under specified conditions to obtain the two-dimensional energy density spectrum of the height variations on the sea surface. This is accomplished by analyzing the diffraction pattern of the density variations on the sea photograph and relating it to the energy density spectrum. In addition, studies of the ocean wave spectra are being made from an EC-121 platform to determine the magnitude and variability of the sea surface.

(*g*) The Sea Photo Analysis (SPA) technique has been verified by simultaneous measurement of the sea surface variation by SPA and by wave staffs. The technique has also been verified in laboratory wave tanks. Work is continuing to use SPA on aerial photos taken from the EC-121 platform.

(*h*) **Determination of Ocean Surface Descriptors Using Sea Photo Analysis Techniques,** R. O. Pilon, *NRL Rept. 7574*, July 1973.

Directional Spectra of Surface Waves from Photographs, D. Stilwell, Jr., R. O. Pilon, *J. Geophys. Res.* **79,** 9, pp. 1277-1284, Mar. 1974.

338-08523-250-20

DRAG REDUCTION

(*b*) Office of Naval Research and Naval Ship Systems Command.

(*c*) R. C. Little, Code 6170.

(*d*) Experimental and theoretical applied research.

(*e*) Combined experimental and theoretical investigations are being made of the drag reducing ability of polymers and association colloids in both aqueous and nonaqueous environments. An improved understanding of the mechanism of drag reduction will allow the synthesis of even more effective agents for both Naval and civilian applications. The ultimate objective of the project is to relate the observed drag reduction effect to the molecular and micellar structure of the agents used.

(*g*) The current progeam is concerned with the effect of various solutes on the drag reduction properties of water-soluble polymers, and the development of information on the drag reduction of monodisperse polymers. Two classes of solutes, salts and surfactants, have been investigated to date. Salts are important since many drag reduction applications will be in sea water. Surfactants, on the other hand, are known to form complexes with certain polymers. Current research shows the commercial polyacrylamides are superior to polyethylene oxides in resisting the depressant effect of highly ionic environments. Surfactants at very low concentration also depress drag reduction, however at higher concentrations they form complexes with the polymers which greatly enhance their activity – almost by a factor of two in some cases. The polystyrene research suggests that the effectiveness of polydisperse commercial agents is due primarily to a relatively small proportion of extremely high molecular weight material. Degradation tests on the monodisperse polymers revealed a superior resistance to breakdown when compared to polydisperse materials of nominally the same viscosity-average molecular weight.

(*h*) **On the Role of Adsorption in the Drag Reduction Effect,** P. Peyser, R. C. Little, *J. Appl. Polym. Sci.* **18,** p. 1261, 1974.

Turbulent Friction Reduction by Aqueous Poly(Ethylene Oxide) Polymer Solutions as a Function of Salt Concentration, R. C. Little, R. L. Patterson, *J. Appl. Polym. Sci.* **18,** p. 1529, 1974.

The Correlation of Drag-Reduction Effects with Polymer Intrinsic Viscosity, O. K. Kim, R. C. Little, R. Y. Ting, *J. Coll. Interf. Sci.* **47,** p. 530, 1974.

Polymer Structures and Turbulent Shear Stability of Drag Reducing Solutions, O. K. Kim, R. C. Little, R. L. Patterson, R. Y. Ting, *Nature* **150,** p. 408, 1974.

Cavitation Suppression by Polymer Additives: Concentration Effect and Implication on Drag Reduction, R. Y. Ting, *AIChE J.* **20,** p. 827, 1974.

The Drag Reduction Phenomenon: Observed Characteristics, Improved Agents and Proposed Mechanisms, R. C. Little, D. L. Hunston, O. K. Kim, R. L. Patterson, R. Y. Ting, R. J. Hansen, *NRL Rept. 7758*, 1974.

An Interdisciplinary Approach to the Study of Turbulent Drag Reduction, R. Y. Ting, R. C. Little, D. L. Hunston, O. K. Kim, R. L. Patterson, *Proc. 2nd Symp. Fluid-Solid Interactions*, June 1974.

The Physio-Chemical Properties of Polymers in Turbulent Drag Reduction, D. L. Hunston, O. K. Kim, R. C. Little, R. L. Patterson, R. Y. Ting, *Proc. 1974 USN ORHAC Mtg.*, NUSC, Newport, R. I., Oct. 1974.

An Experimental Study of the Hydrodynamic Drag on Compliant Surfaces: Fluid Property Effects, R. J. Hansen, D. L. Hunston, *Proc. 8th Intl. Congr. Acoustics*, Goldcrest Press, London, 1974.

An Experimental Study of Turbulent Flows over Compliant Surfaces, R. J. Hansen, D. L. Hunston, *J. Sound and Vibration* **34,** p. 297, 1974.

Drag Reduction in Polymer Mixtures and the Effect of Molecular Weight Distribution, D. L. Hunston, *Nature, Phys. Sci.* **251,** p. 697, 1974.

Stability and the Laminar-to-Turbulent Transition in Pipe Flows of Drag-Reducing Polymer Solutions, R. J. Hansen, R. C. Little, M. M. Reischman, M. D. Kelleher, *Proc. BHRA Conf. on Drag Reduction*, Cambridge, U. K., Sept. 1974.

The Interaction of Sodium Dodecyl Sulfate and Polyethylene Oxide, R. L. Patterson R. C. Little, *Nature, Phys. Sci. Section.*

Experimental Evidence Connecting the Early Turbulence and Drag Reduction Phenomena in Larger Pipes, R. J. Hansen, R. C. Little, *Nature, Phys. Sci. Section.*

338-08524-250-00

STABILITY OF LAMINAR PIPE FLOWS OF DRAG-REDUCING POLYMER SOLUTIONS

(*c*) R. J. Hansen.

(*d*) Experimental and theoretical basic research.

(*e*) Experimental and theoretical work is conducted to determine the effects of polymer additives on the transition Reynolds number, the nature of the laminar to turbulent transition, and the implications of the results for applying the drag reduction phenomenon to systems of practical interest. Experimental techniques employed include pressure

drop-flow rate measurements and laser Doppler anemometry.

(*g*) In pipes of small diameter or with solvents of large viscosity, polymer additives increase hydrodynamic drag above an onset shear stress in the laminar regime, modify the fundamental character of the laminar-to-turbulent transition, and reduce drag in the fully turbulent regime. This behavior has recently been observed in polyacrylamide as well as polyethylene oxide solutions, and the onset condition for increased drag has been shown independent of pipe inlet configuration. The theoretical work has shown that an additive may exert a stabilizing or a destabilizing influence on the flow, depending on the magnitudes of relevant geometric and viscometric parameters. Consideration of a typical hydraulic system suggests that a drag-reducing additive might have the desired effect in some portions of the system but the opposite effect in others.

(*h*) **Experimental and Theoretical Studies of Early Turbulence,** R. J. Hansen, R. C. Little, P. C. Forame, *J. Chem. Engrg. Japan* **6**, 4, pp. 310-314, 1973.
Stability and the Laminar to Turbulent Transition in Pipe Flows of Drag-Reducing Polymer Solutions, R. J. Hansen, R. C. Little, M. M. Reischman, M. D. Kelleher, *Paper B4, Intl. Conf. Drag Reduction*, Sept. 4-6, 1974.

338-09418-010-22

TURBULENT STRUCTURE OF GEOPHYSICAL BOUNDARY LAYERS

(*b*) Department of the Navy.
(*c*) Mr. Clifford Gordon, Code 8342.
(*d*) Field studies of the benthic boundary layer in an estuary including measurements of Reynolds stress, turbulent kinetic energy and velocity profiles.
(*e*) Establish whether the findings of contemporary wind tunnel and laboratory boundary layer investigations are directly applicable to the large scale turbulent structure of geophysical boundary layers. The most specific interest is in the scaling behavior of the bursting phenomenon.
(*g*) Direct measurements have shown that most of the vertical transport of horizontal momentum in a marine boundary layer occurs intermittently; 90 percent of the transport takes place in about 30 percent of the time.
(*h*) **A Pivoted-Vane Current Meter,** C. M. Gordon, C. F. Dohne, *Ocean* **73**, pp. 46-49, IEEE, Inc., N. Y., 1973.
Some Observations of Turbulent Flow in a Tidal Estuary, C. M. Gordon, C. F. Dohne, *J. Geophys. Res.* **78**, pp. 1971-1978, Apr. 20, 1973.
Intermittent Momentum Transport in a Geophysical Boundary Layer, C. M. Gordon, *Nature* **248**, pp. 392-394, Mar. 29, 1974.
The Period Between Bursts at High Reynolds Number, C. M. Gordon, *Phys. Fluids*, Feb. 1975.

338-09419-030-22

VORTEX-INDUCED VIBRATION OF UNDERSEA CABLES

(*b*) Naval Facilities Engineering Command.
(*c*) Steven E. Ramberg, Owen M. Griffin.
(*d*) Applied experimental research.
(*e*) The wake structure (e.g., vortex formation length), spanwise correlation of vortex shedding, and transverse resonant properties of several cables have been examined to gain insight into the cable strumming phenomenon and to serve as a basis for a predictive engineering model.
(*g*) These experiments have demonstrated that the spanwise variation of fluid forces on a strumming cable is principally related to local amplitude of motion. Using this observation, an extension of an existing heuristic model for vortex-induced oscillations of rigid cylinders to oscillations of flexible cylinders has been attempted. The extended model requires a knowledge of the modal damping and added mass in water to predict the resonant response. If the resonant properties, damping and added mass, are combined into a single stability parameter, the maximum strumming amplitude is a function of only this parameter. Some representative values of cable damping and added mass in water have been ascertained and utilized to verify the model by comparison with published cable strumming data.
(*h*) **Vortex Formation in the Wake of Vibrating Flexible Cables,** S. E. Ramberg, O. M. Griffin, *ASME J. Fluids Engrg.* **96**, 4, Dec. 1974.
Velocity Correlations and Vortex Spacing in the Wake of a Vibrating Cable, S. E. Ramberg, O. M. Griffin, *ASME J. Fluids Engineering*.
Some Transverse Resonant Properties of Wire Rope with Application to Cable Strumming, S. E. Ramberg, O. M. Griffin, *NRL Rept. 7821*, Dec. 1974.

338-09420-250-00

INTERACTION OF A SHEAR FLOW WITH A COMPLIANT BOUNDARY

(*c*) R. J. Hansen.
(*d*) Experimental and theoretical basic research.
(*e*) The effects of surface compliance on boundary layer flows is examined experimentally and theoretically. Of particular interest are alterations in skin friction drag due to surface compliance and deformations in the surface caused by the fluid.
(*g*) Experiments with a rotating disk apparatus have established that, over the range of parameters examined thus far, surface compliance has no effect on skin friction below a critical free stream fluid velocity (rotational speed). This critical condition depends on the properties of both the liquid and the compliant solid. Above the critical condition the drag is significantly increased by surface compliance due to the development of a hydroelastic instability in the form of a wave structure in the compliant surface-liquid interface. The critical condition can occur in the laminar or the turbulent flow regime, depending on the liquid viscosity. The critical velocity increases with increasing fluid viscosity and compliant material elastic modulus, but it is not altered significantly by drag-reducing polymer additives.
(*h*) **An Experimental Study of Turbulent Flows Over Compliant Surfaces,** R. J. Hansen, D. L. Hunston, *J. Sound and Vibration* **34**, 3, pp. 297-308, 1974.
An Experimental Study of the Hydrodynamic Drag on Complaint Surfaces: Fluid Property Effects, *Proc. 8th Intl. Cong. Acoustics* **2**, p. 579, London, 1974.

U. S. NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, CARDEROCK LABORATORY, Bethesda, Md. 20084. W. E. Cummins, Head, Ship Performance Department.

339-08526-230-00

HYDRODYNAMIC CAVITATION STUDIES

(*c*) Dr. F. B. Peterson, Hydrodynamics Branch.
(*d*) Experimental work primarily; basic and applied research.
(*e*) Determination of physical properties of water and bodies which are responsible for cavitation inception and associated noise and erosion. Development of techniques for the measurement of cavitation inception and noise and their associated scaling laws.
(*g*) Holographic technique developed to measure the free gas and particulate content of water. Boundary layer properties have been calculated and correlated with experiments for the prediction of cavitation inception on model and full-scale bodies.
(*h*) **Hydrodynamic Cavitation and Some Considerations of the Influence of Free Air Content,** F. Peterson, *Proc. 9th Symp. Naval Hydrodyn.*, Paris, 1972.
Some Considerations of Material Response Due to Liquid-Solid Impact, F. Peterson, *J. Fluids Engrg.* **95**, 1, pp. 263-270, 1973.
Physics Associated with Cavitation Induced Material Damage, F. Peterson, *Nat. Bur. Standards, Publ. 394*, 1974.

Comparative Study of U. S., German, and French Methods to Measure Bubbles and Solid Particles in Water, F. Peterson, et al., presented *14th Intl. Towing Tank Conf.*, Ottawa, Sept. 1975.

339-08529-040-22

TWO-DIMENSIONAL ADDED-MASS AND DAMPING FOR BODIES OSCILLATING IN A FLUID OF FINITE DEPTH

(*b*) Naval Ship Systems Command.
(*c*) Mr. D. J. Sheridan, Ship Performance Department.
(*d*) Theoretical; applied research.
(*e*) A method for predicting the two-dimensional added-mass and wave damping for arbitrary bodies was developed for shallow water flows using a closefit source distribution technique.
(*f*) Discontinued.
(*g*) The potential function for a single source oscillating in a fluid of finite depth has been developed.

339-08530-550-00

SKEWED PROPELLER DEVELOPMENT

(*c*) Dr. W. B. Morgan, Head, Hydromechanics Division, Code 154.
(*d*) Experimental; development.
(*e*) The effect of blade warp (a combination of skewback and forward rake which places the centerline of all blade sections in the same plane normal to the shaft axis) has been investigated. Forward rake, such as that used in this investigation, increases the strength and clearance from downstream appendages compared to skewed propellers without rake. Two warped propellers have been built to model scale and evaluated. These propellers differ from existing propellers only in that blade warp rather than blade skew is used. The model propellers have been evaluated for cavitation inception and patterns, for propeller-induced pressures, and for unsteady bearing forces and moments. These results have been correlated with results of existing corresponding skewed propellers.
(*f*) Completed.
(*g*) Open-water results showed that arbitrary raking without pitch corrections did not prove satisfactory. Cavitation results for the warped propellers showed a widening of the cavitation-free bucket for increasing warp – a trend similar to that found for increasing skew. The propeller-induced pressures and the unsteady propeller forces and moments have been found to decrease with increasing warp to reductions achieved with blade skew.
(*h*) **Experimental Evaluation of a Series of Skewed Propellers with Forward Rake: Open-Water Performance, Cavitation Performance, Field-Point Pressures, and Unsteady Propeller Loading,** J. J. Nelka, *NSRDC Rept. 4113*, July 1974.

339-08531-550-22

CONTRAROTATING PROPELLERS

(*b*) Naval Sea Systems Command.
(*c*) E. B. Caster, Mathematician, Propulsor Technology Branch.
(*d*) Theoretical; development.
(*e*) To apply recent advances in propeller design-theory and numerical computation procedures to the design of contrarotating propellers and thus permit improvements in the propeller operational characteristics including cavitation performance and vibration characteristics.
(*f*) Theoretical work completed; experimental phase awaiting funds.
(*g*) A report of work in (e) to be issued in 1975 will include a FORTRAN listing of the contrarotating propeller design computer program adaptable to the CDC 6700 high speed computer.

339-08532-550-22

DESIGN AND PERFORMANCE PREDICTION OF CONTRAROTATING PROPULSION ARRANGEMENT

(*b*) Naval Sea Systems Command.
(*c*) Dr. W. B. Morgan, Code 154.
(*d*) Theoretical; applied research.
(*e*) Develop a capability for accurate prediction and design of ships with contrarotating propulsion arrangement. The hull-propeller interaction phenomena associated with contrarotating propulsion arrangements will be investigated through programs combining model experiments and analytical study. Experimental program will be used to explore propulsor and control surface interaction, and interaction between hull, propulsor, and control surfaces. Factors to be investigated include loading between propellers, spacing of propellers, location and type of control surfaces, etc. Analytical study will be carried out on specific submarine and/or surface ships. Components of propulsive coefficients will be calculated by means of available propeller computer program and application of the Lagally steady-motion theorem. Theoretical results will be compared with experimental results.
(*f*) Completed.
(*g*) Experiments for a surface-ship model have been completed. A report of work in (e) will be issued in 1975.

339-08533-550-22

BLADE TURNING EFFORT OF CONTROLLABLE PITCH PROPELLERS

(*b*) Naval Sea Systems Command.
(*c*) Stephen B. Denny.
(*d*) Experimental; development.
(*e*) Provide data applicable to the prediction of blade turning effort and blade spindle strength requirements of CP propellers. Such propellers offer advantages over fixed-pitch propellers of backing without shaft reversal and potential cavitation and noise reductions by virtue of their capability to develop a given speed through various combinations of pitch settings and rpm. No reliable data are available for predicting blade turning effort and blade spindle requirements. Instrumentation was developed and spindle torque was measured on a wide-bladed model CP propeller over a wide range of operating conditions (advance coefficients and pitch settings).
(*g*) Blade spindle moment was determined experimentally for a series of four controllable-pitch (C-P) propellers. The propellers of the series were five-bladed and the series exhibited variation in blade skew and blade area. The experiments were conducted in open water in the towing basin at the Naval Ship Research and Development Center (NSRDC). Blade spindle moment values due to hydrodynamic and centrifugal forces were determined. These values were determined in steady state operating conditions for a large range of blade pitch settings and for the range of controllable-pitch propeller advance between the "locked shaft" ahead and "locked-shaft" astern operating conditions. Dynamometry and experimental procedures have been developed and used successfully in the simultaneous measurement of spindle moment and propeller thrust and torque in open water. The spindle moment data will enable designers of C-P propeller systems to estimate blade spindle moment loads and the input power necessary to rotate C-P blades during maneuvers.
(*h*) **Blade Spindle Moment on Controllable-Pitch Propellers,** *NAVSHIPRANDCEN, Ship Performance Dept. Rept. SPD-011-14*, July 1974.
Open Water Performance of a Controllable-Pitch (C-P) Propeller Series, *NAVSHIPRANDCEN, Ship Performance Dept. Rept. SPD-011-13*, July 1974.

339-08536-550-22

PREDICTION OF PROPELLER INDUCED SHIP VIBRATION

(*b*) Naval Sea Systems Command.
(*c*) Stephen B. Denny.
(*d*) Experimental; development.
(*e*) Extend procedures and instrumentation capabilities to enable measurement of total resultant unsteady forces on sterns of surface ship models. Develop instrumentation design to allow measurement of all six components of moments and forces on the stern section of a surface ship model. These tests should furnish information about the

total resultant forces (rather than localized forces) on an appendaged hull propeller arrangement.
(*f*) Discontinued.

339-08540-250-00

POLYMER DRAG REDUCTION AND DEGRADATION STUDIES

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental and theoretical work; basic research.
(*e*) Experimental characterization of polymer drag-reduction by pipe flow tests and shear degradation in rotating disk tests. Use of data to develop reliable drag-reduction prediction techniques for plates and bodies.
(*g*) Gross characterization of polymer drag reduction and degradation have been completed.
(*h*) **Similarity Laws for Turbulent Flow of Dilute Solutions of Drag-Reducing Polymers,** T. T. Huang, *Phys. Fluids* **17**, 2, pp. 298-309, Feb. 1974.

339-08542-520-00

SHIP RESISTANCE COMPONENTS

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental work primarily; applied research.
(*e*) Shear stress pressure distribution, wake velocity, streamlines, and waves are being measured for a Series 60/Block 60 surface ship model. The directionality of shear stress is determined from high aspect ratio hot films. The data will serve as a base for development and verification of resistance prediction techniques.
(*g*) Shear stress, pressures and wake measurements completed.
(*h*) **Shear Stress and Pressure Distribution on a Surface Ship Model,** T. T. Huang, C. H. von Kerczek, presented *9th Symp. Naval Hydrodyn.*, Paris, Aug. 1972.

339-08544-520-22

SPINNING CYLINDERS IN CONTROL SURFACE

(*b*) Naval Sea Systems Command.
(*c*) Mr. R. S. Dart, Ship Performance Department.
(*d*) Experimental; applied research.
(*e*) The feasibility of employing spinning cylinders in the trailing edges of submarine control surfaces to obtain lift with zero plane angle was determined experimentally with an approximately 15-inch x 15-inch control surface and 1.5-inch diameter cylinder.
(*f*) Discontinued.
(*g*) From the results of the experiments mathematical expressions were derived for the lift developed on the control surface with a spinning cylinder at the trailing edge and the hydrodynamic power required as a function of the cylinder RPM.

339-08545-520-22

APPENDAGE INFLUENCE ON THE FORCES ON A SUBMARINE

(*b*) Naval Sea Systems Command.
(*c*) Dr. C. M. Lee, Ship Performance Department.
(*d*) Experimental; applied research.
(*e*) The influence of the appendage combinations on the longitudinal normal force and pitching moment distributions was determined using a segmented model and conducting captive-model tests.
(*f*) Discontinued.
(*g*) From the results of the experiments the influence of the bridge fairwater and of various combinations of stern appendages on the normal force and pitching moment distributions on submarine bodies or revolution were determined.

339-09421-520-22

ADVANCED UNMANNED SEARCH SYSTEM (AUSS)

(*b*) Naval Sea Systems Command.
(*c*) William J. Von Feldt, Towed Systems Branch.
(*d*) Theoretical; design.
(*e*) Apply existing steady-state cable programs to the design of a low speed tethered-free swimming vehicle which is to be used at a Test Bed Vehicle (TBV) for evaluation of present and future search sensors and operational concepts. Operation depths of interest are 2,000 to 20,000 feet. Tow tether cables are involved. The primary tether cable is 25,000 feet long of double-armored steel construction. The secondary tether cable is 2,000 feet long, neutrally buoyant, and of PRD-fiber construction.
(*g*) The addition of ribbon fairing over the entire length of the primary tether cable provides greatly improved depth-to-scope ratios without adding severe mechanical complications.

339-09422-030-22

STRUM SUPPRESSION OF TOWED ARRAY TOWLINES

(*b*) Naval Electronics Systems Command; Office of Naval Research.
(*c*) Paul Rispin, Towed Systems Branch.
(*d*) Experimental work; development.
(*e*) Basin experiments were performed to evaluate the effectiveness of various strum-suppressant cable attachments. Both standard and newly-developed methods were examined. The study has determined optimum design criteria for cables used for shallow angle tows in the Towed Array Program.
(*g*) Spiral wraps, ribbon trailings, and stubs have been shown to be useful in reducing strum acceleration amplitudes.

339-09423-430-22

LARGE DISPLACEMENT CABLE DYNAMICS

(*b*) Civil Engineering Laboratory, Naval Construction Batallion Center.
(*c*) J. H. Pattison, R. P. Para, Towed Systems Branch.
(*d*) Experimental; applied research.
(*e*) Laboratory experiments will be conducted to obtain experimental data for assessment of the predictive capabilities of the numerical models used to describe the large-scale dynamic motions of subsurface cable structures.
(*g*) Study to be completed in 1975.

339-09424-030-22

MOORING CABLE STRUM INVESTIGATION

(*b*) Civil Engineering Laboratory.
(*c*) J. H. Pattison, J. F. Stasiewicz, Towed Systems Branch.
(*e*) Collect experimental data on the hydrodynamics of a strumming cable in a flow. Cable oscillation frequency, displacement amplitude profile, tension fluctuations, and drag vector components will be measured when the vortices are shedding in resonance with the natural frequency of the cable. Experiments will include the investigation of tensioned and slack cables both in uniform flow and flow gradients. Results will be used to model full-scale cable moorings and to evaluate contemporary predictive analytical models.
(*g*) Experiments to be conducted in June 1975.

339-09425-030-22

DEVELOPMENT AND PERFORMANCE PREDICTIONS OF CABLE FAIRING

(*c*) John V. Mirabella, Towed Systems Branch.
(*d*) Experimental applied research and development.
(*e*) Improve the performance and reliability of cable fairings. Of primary concern are the selection of fairing shape, type of construction and material, and the determination of the fairing stability, symmetry and hydrodynamic loading. Work is presently being done in the development of an integrated fairing for high-speed use. An additional aspect of the program is to determine the normal and tangential hydrodynamic loading on cable fairings which is used to predict the catenary shape for a towed or moored system. This is accomplished through model towing or backfitting at-sea data.

(*g*) Much work has been done in the past with the TMB Cable Fairing Dynamometer. This work has been compiled and is being issued in a single report which is now in review.
(*h*) **Experimental Determination of Hydrodynamic Loading for Ten Cable Fairing Models,** R. Folb, *NAVSHIPRANDCEN Rept. 4610*.

339-09426-700-44

HYDRODYNAMIC SUPPORT - NATIONAL DATA BUOY PROGRAM

(*b*) National Oceanic and Atmospheric Administration - Data Buoy Office.
(*c*) J. H. Pattison, Towed Systems Branch.
(*d*) Experimental work; design.
(*e*) Determine the hydrodynamic characteristics of various components for deep ocean, oceanographic data mooring. Components include various buoys, mooring lines, and subsurface sensor packages. Data is used by sponsor to evaluate various components for reliability and suitability and to predict system performance.
(*g*) Dynamic responses of a mooring line to motions of a surface buoy were simulated in the Circulating Water Channel. In separate experiments, various components, including subsurface current sensors, were subjected to simulated mooring line motions.
(*h*) **Components of Force Generated by Harmonic Oscillations of Small-Scale Mooring Lines in Water,** J. H. Pattison, *NAVSHIPRANCEN Ship Performance Dept. Rept. SPD-589-01*.

339-09427-700-44

CURRENT SENSOR MOORING EXPERIMENTS

(*b*) National Oceanic and Atmospheric Administration, National Ocean Survey, and National Oceanographic Instrumentation Center.
(*c*) J. H. Pattison, R. P. Para, Towed Systems Branch.
(*d*) Experimental work; operation.
(*e*) Evaluate hydrodynamic performance of current meters under simulated mooring line motions in the Circulating Water Channel. Data is used by the sponsor to choose various current meters for specific applications and to modify the current meters as required.
(*g*) Several different current meters, including the conventional savonius rotor types and prototype electro-magnetic and acoustic types have been evaluated.
(*h*) **Aanderaa Current Meter Test, Evaluation and Modification,** D. R. Schmidt, *10th Ann. Conf. Marine Tech. Soc.*, Sept. 1974.

339-09428-030-22

HYDRODYNAMIC EVALUATION OF SONOBUOY AND ARRAY COMPONENTS

(*b*) Naval Air Development Center.
(*c*) J. H. Pattison, Towed Systems Branch.
(*d*) Experimental work; design.
(*e*) Conduct experiments in the towing basins and flow tanks to determine the hydrodynamic characteristics of various components of suspended and towed array systems. Components include compliant suspension lines, hydrodynamic dampers, drogues, and hydrophone arrays. Data is used by sponsor in system design and evaluation.
(*g*) Hydrophone arrays were towed to determine drag and stability characteristics under simulated ocean current conditions.

339-09429-550-22

DESIGN CONCEPTS FOR ADVANCED CONTROLLABLE-PITCH PROPELLERS

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell, Code 1544.
(*d*) Experimental; development.
(*e*) An investigation is underway to determine and evaluate from hydrodynamic considerations, methods and concepts to improve the strength, efficiency, cavitation performance, and vibratory characteristics of controllable-pitch (CP) propellers with extremely high loading. The concept of a set of tandem propellers has been selected for initial detailed evaluation. Propulsion and cavitation experiments have been conducted on a set of tandem propellers. The longitudinal and angular spacing between the two propellers was varied during these experiments.
(*g*) Experimental results indicate that tandem propellers can have propulsion and cavitation performance comparable to that of single propellers. Propulsion and cavitation performance varies slightly with longitudinal and angular spacing between the two propellers.
(*h*) **Cavitation and Open Water Performance of a Set of Tandem Propellers,** R. D.D. Kader, *NSRDC, Ship Performance Dept. Evaluation Rept. SPD-592-01*, Nov. 1974.

339-09430-550-00

WATERJET PUMP DEVELOPMENT FOR SHIP PROPULSION

(*c*) R. S. Alder.
(*d*) Theoretical and experimental; applied research.
(*e*) To incorporate current available theoretical procedures for the design of conventional and supercavitating propellers into the design of a waterjet impeller/stator system in order to improve pump efficiency and/or impeller cavitation performance and the overall efficiency of waterjet systems. Waterjet propulsor systems fulfill specialized power requirements where appendage and draft restrictions are critical to maneuverability and overall performance of the ship.
(*g*) Performance tests have been completed on a 31-ft waterjet-powered planing craft equipped with a redesigned impeller. Inlet velocity measurements were also obtained in the experiments. Experimental results are presently being analyzed. Further waterjet testing is planned using a static test stand.

339-09431-550-22

BLADE LOADING OF CONTROLLABLE PITCH PROPELLERS

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell, Code 1544.
(*d*) Experimental; development.
(*e*) A combined experimental and analytical program is underway to develop improved techniques for predicting blade loading of controllable-pitch propellers over a complete range of operating conditions. This is necessary in order to improve the design technology and structural reliability of controllable pitch propellers. In FY 75, the six components of blade loading will be measured behind a model hull under the following simulated conditions: steady ahead, crash back, high speed turns, and ship motions. Dependent upon the conditions simulated, the time average, transient, and unsteady portions of each component of blade loading will be determined. In subsequent years, blade loading will be measured on additional propeller-hull combinations, blade stresses and pressures will be measured on controllable-pitch propellers under various simulated conditions, and improved prediction techniques for blade loading will be developed based on experimental results and theoretical formulations.
(*g*) Preparation for experiments is underway.

339-09432-550-22

PROPELLER BLADE PRESSURE DISTRIBUTION

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell, Code 1544.
(*d*) Experimental; development.
(*e*) Provide experimental measurements of the pressure distribution on models of marine propellers. Measurements will be made with the propellers operating in uniform flow and in simulated ship wakes for design conditions and for off-design conditions including backing, crash back and crash ahead operations. This information is required in order to evaluate the theoretical methods being developed

for predicting the hydrodynamic performance and strength of ship propellers.

A method has been developed for mounting a miniature pressure gage in a cavity within the propeller blade with an orifice leading to the blade surface. This is only suitable for the thicker portions of the blade. Other methods will be developed for use near the blade tips and edges. One propeller has been gaged on both sides along the section at 0.7 of the radius. Pressure measurements have been made in uniform flow in the water tunnel and in the towing basin at design and off-design conditions.

(*g*) Measurements made in the two facilities have shown good agreement and repeatability. The results are being analyzed and compared with calculated values obtained by using available theoretical methods. This project will continue with the development of methods for extending the measurements over a greater portion of the blade surface and for measuring unsteady pressures when operating in nonuniform flow.

339-09433-530-22

HYDROFOIL NOSE RADIUS EFFECT ON INCIPIENT CAVITATION

(*b*) Naval Sea Systems Command.
(*c*) Daniel T. Valentine, Mechanical Engineer, Propulsor Technology Branch, Code 1544.
(*d*) Theoretical; applied research.
(*e*) Determination of the cavitation-inception characteristics of modified marine propeller-type hydrofoils. In particular, determination of dependence of the critical cavitation number and the cavitation-free, angle-of-incidence range on changes in the leading-edge thickness.
(*f*) Completed.
(*g*) Within a narrow range of leading edge thickness changes a delay in cavitation inception is possible, depending on the design problem under consideration. An increase in critical inception speed, accompanied by a sacrifice in some of the cavitation-free, angle-of-incidence range occurs for small increase in the leading edge thickness. A range of thickness changes exist for which beneficial results can be obtained.
(*h*) **The Effect of Nose Radius on the Cavitation-Inception Characteristics of Two-Dimensional Hydrofoils,** D. T. Valentine, *NSRDC Rept. 3813*, July 1974.

339-09434-550-00

PROPELLER DESIGN THEORY FOR HIGHLY SKEWED PROPELLERS

(*c*) Dr. T. Brockett, Propulsor Technology Branch, Code 1544.
(*d*) Theoretical; applied research.
(*e*) Numerical analysis and computer program are being developed for an analytical formulation of the propeller design problem which includes the effect of the radial component of the blade-surface normal vector. Propellers with large variations in warp (or skew) angle, rake, or pitch can have a significant radial component. Unless the effect of this radial component is properly accounted for, uniformly satisfactory cavitation and powering performance is not likely to be achieved.
(*g*) Analytical basis available in NSRDC Report 3880; computer program operational; experimental validation initiated.

339-09435-550-00

UNSTEADY FORCES ON CONTRAROTATING PROPELLERS

(*d*) Experimental; development.
(*e*) Determine experimentally the unsteady forces on models of contrarotating marine propellers. When contrarotating propellers operate in uniform flow unsteady forces are generated due to the interaction of the propellers as the blades pass each other. In the wake of a ship additional excitation is furnished by the nonuniform inflow. These unsteady forces set up vibrations that can cause damage to the propellers and ship structure. At present the only way to predict the unsteady forces is by making measurements on model propellers. Theoretical methods are being developed also but the experimental results will be required to evaluate them.
(*g*) A six component propeller dynamometer has been adapted for use with contrarotating propellers in the water tunnel. Experimental procedures and methods for data analysis have been developed. Unsteady forces and moments have been determined for 4 x 4 and 4 x 5 bladed propeller sets in uniform flow. Strong periodic forces were observed with those on the upstream propeller being thc larger. These results will be used to evaluate a theoretical procedure now being developed for calculating these forces. Future work will include the same propellers in simulated ship wakes and other propeller designs.

339-09436-550-00

TANDEM PROPELLER DESIGN

(*c*) Stephen B. Denny.
(*d*) Theoretical; experimental, design.
(*e*) A procedure has been developed for the design of tandem propellers. The specific tandem propeller arrangement considered is two propellers operating one behind the other, on the same shaft with the same rotational speed and direction of rotation. The procedure has been proven valid for the design of tandem units operating in uniform inflow and should be applicable to wake-adapted design cases. The ability to design tandem propeller units which meet prescribed performance criteria and which operate at acceptable propeller efficiencies could have considerable impact on ship powering technology. Tandem propellers can be applied to ships with high delivered horsespower, where vibration and cavitation erosion are anticipated problems, and where the physical constraints make a tandem arrangement attractive.
(*g*) A tandem propeller unit designed using this method was constructed and evaluated in open-water experiments. The performance data showed that the unit produced the desired thrust at the design revolution rate and that the open-water efficiency was as good as a single propeller carrying the same load at the same operating conditions.

339-09437-010-00

STRUCTURE OF BOUNDARY LAYERS AND TURBULENCE WITH APPLICATION TO DRAG REDUCTION, NOISE GENERATION, AND WAKE DETECTION

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental work, basic research.
(*e*) Measure the structure of hydrodynamic turbulence by hot-film anenometers and Laser Doppler Velocimeter (LDV) in boundary layers, wakes, and jets, with emphasis on data relevant to drag reduction, noise generation, wake detection and diffusion.
(*g*) Hot-film measurements and detail computation of the structure of high Reynolds number turbulence behind a grid in a water tunnel have been completed. LDV measurements of turbulence in a 2-inch pipe with and without drag reduction have also been completed.

339-09438-010-00

LAMINAR FLOW BODIES

(*c*) P. S. Granville, K. P. Kerney, Naval Hydromechanics Division.
(*d*) Theoretical; applied research.
(*e*) Analytical methods are being devised to predict viscous drag of bodies of revolution with maximum laminar boundary layer and hence, minimum drag.
(*g*) See (h).
(*h*) **The Prediction of Transition from Laminar to Turbulent Flow in Boundary Layers on Bodies of Revolution,** P. S Granville, *NSRDC Rept. 3900*, Sept. 1974.

339-09439-520-00

VISCOUS DRAG OF SURFACE SHIPS

(*c*) P. S. Granville, Naval Hydromechanics Division.
(*d*) Theoretical; applied research.
(*e*) Analytical method is developed for predicting the viscous drag of surface ships which is required in extrapolating the total drag of ship models to full-scale conditions by the classical Froude method. The surface ship geometry is converted into that of an equivalent body of revolution.
(*g*) See (h).
(*h*) **A Modified Froude Method for Determining Full-Scale Resistance of Surface Ships from Towed Models,** *J. Ship Res.* **18,** 4, Dec. 1974.

339-09440-000-00

YAWED PLATE PIERCING A FREE SURFACE

(*c*) Dr. R. B. Chapman, Hydrodynamics Branch.
(*d*) Numerical-theoretical study; applied research.
(*e*) The steady 3-D disturbance for a yawed plate piercing a free surface is simulated by solving the related 2-D unsteady problem of a partially submerged plate translating normal to its plane.
(*g*) Cases with linear and nonlinear free-surface boundary conditions have been computed.

339-09441-550-00

PROPELLER-HULL INTERACTION

(*c*) J. H. McCarthy, Hydrodynamics Branch.
(*d*) Experimental and theoretical work; applied research.
(*e*) Development of theoretical and computational methods to predict the effect of a propeller on thrust deduction and wake fraction. Experiments to determine propeller-induced boundary-layer velocity perturbations will be made with a laser-Doppler velocimeter.
(*g*) Theoretical work has been completed.

339-09442-030-00

FLOW TRANSITION AND TURBULENCE STIMULATION

(*b*) Naval Sea Systems Command..
(*c*) J. H. McCarthy, Hydrodynamics Branch.
(*d*) Experimental work primarily; applied research.
(*e*) Determination of the locations of flow transition and laminar separation on axisymmetric models at Reynolds numbers up to 4 x 10^7. Determination of effective turbulence-stimulation techniques and development of improved methods for predicting prototype drag from model drag measurements.
(*g*) Experiments on four bodies have been completed.

339-09443-520-22

NAVAL SHIP SEAKEEPING PREDICTION

(*b*) Naval Sea Systems Command.
(*c*) Dr. Nils Salvesen, Hydrodynamics Branch.
(*d*) Theoretical work, applied research.
(*e*) Provide new and improved theoretical formulations and computer programs by which reliable Naval ship seakeeping predictions can be made.
(*g*) See publications.
(*h*) **Second-Order Steady-State Forces and Moments on Surface Ships in Oblique Regular Waves,** N. Salvesen, *Intl. Symp. Dynamics of Marine Vehicles and Structures in Waves,* University College, London, Apr. 1974.
Manual, NSRDC Ship-Motion and Sea-Load Computer Program, W. G. Meyers, D. J. Sheridan, N. Salvesen, *Naval Ship R&D Center Rept. 3376,* 1975.

339-09444-520-20

NUMERICAL HYDROMECHANICS OF NAVAL VEHICLES

(*b*) Office of Naval Research and Naval Sea Systems Command.
(*c*) Dr. Nils Salvesen, Hydrodynamics Branch.
(*d*) Numerical and theoretical; applied research.
(*e*) Develop direct numerical methods for the prediction of those free-surface performance characteristics of Naval ships and advanced vehicles which cannot be satisfactorily predicted by conventional methods. Attention will be focused on the following problem areas: the nonlinear bow-wave; three-dimensional ship wave resistance; and the nonlinear surface-piercing strut.
(*g*) See publications.
(*h*) **Numerical Solutions of Two-Dimensional Nonlinear Wave Problems,** C. H. von Kerczek, N. Salvesen, *ONR 10th Naval Hydrodyn. Symp.,* MIT, June 1974.
A Combined Spectral Finite-Difference Method for Linear and Nonlinear Water Wave Problems, H. J. Haussling, R. T. van Eseltine, *NSRDC, Computation and Mathematics Dept. Rept. CMD-24-74,* 1974.

NAVAL SURFACE WEAPONS CENTER, White Oak, Silver Spring, Md. 20910. Mr. J. Colvard, Technical Director.

341-04867-510-22

HYDROBALLISTICS RESEARCH

(*b*) NAVSEA.
(*c*) Dr. V. C. D. Dawson, Chief, Ballistics Department.
(*d*) Experimental, theoretical; basic and applied research.
(*e*) Under the hydroballistics research program experimental and theoretical research is being conducted to solve immediate and long-range Navy problems in high-speed water entry, underwater launching of ordnance from moving submarines, mine case motion and dynamics, and new weapon system synthesis in these technical areas.
Specifically the water-entry research program is aimed at providing basic data on forces and moments that can be used in the design of Naval ordnance that is required to enter the water at high velocity. As part of the program the ability to predict the complete underwater trajectory of the ordnance after entering the water is also being developed.
In order to accomplish this, extensive studies are being made of the cavity-running phase involving cavity growth and attrition, and cavity pressure. The NAVSURFWPNCEN Hydroballistics Facility measuring 35 ft x 100 ft x 70 ft is ideally suited for these studies since it permits atmospheric pressure reduction for cavitation scaling.
The underwater launch program is directed at establishing the actual flow conditions, forces and moments that exist during the launch of the missiles or torpedoes from moving submarines. The ultimate goal is to increase the weapon launch capability and flexibility of existing and future Naval submarines.
(*g*) Results of recent studies include prediction of water-entry impact drag coefficients for cones, ogives, blunt nose shapes; experimental determination of cavity pressure and approximate techniques for estimating cavity size. Shock spectra for blunt nose mine shapes have been obtained from model tests which agree with full-scale tests. Methods of stabilizing slender vehicles so that they can enter the water at high speed and low entry angle without broaching were developed. In the area of underwater launch, a simple method of stabilizing a missile when launched from a vertical tube on a moving submarine was developed.
(*h*) **Oblique Water Entry of High-Speed Cones and Paraboloids,** J. Goeller, R. Hassett, H. Steves, *NOLTR 72-188,* Aug. 1, 1972.
Advanced Cruise Missile (ACM) Model Launch Tests – Phase I, J. Goeller, R. Hassett, H. Steves, R. Waser, W. Hinckley, D. Newell, A. Berger, J. Berezow, *NOLTR 72-257,* Oct. 25, 1972.
Water Entry and Cavity Stabilization of a Torpedo Model, W. Hinckley, L. Taylor, A. Shipley, *NOLTR 73-229,* Feb. 7, 1974.

Underwater Vertical Launch Tests of Models of Various SLCM Concepts, J. Goeller, J. Etheridge, *NOLTR 73-175*, Nov. 26, 1973.
Free-Fall Mine Model Test Program, R. Waser, J. Goeller, J. Etheridge, *NOLTR 74-137*, Aug. 26, 1974.

NAVAL UNDERSEA CENTER, DEPARTMENT OF THE NAVY, San Diego, Calif. 92132.

342-07219-550-22

PROPULSOR DESIGN

(*b*) Naval Ordnance Systems Command.
(*c*) D. M. Nelson, Code 2542.
(*d*) Theoretical, experimental, applied research.
(*e*) Develop advanced theoretical methods for the design of underwater propulsors, to program them for high speed computers, and to apply them to the design of hardware which may be experimentally verified. Work to date has concentrated on the development of a lifting-surface design method for counter-rotating propellers operating on an axisymmetric body.
(*f*) Completed.
(*g*) The two sets of counter-rotating propellers designed to date using the lifting-surface design method performed very close to the design specifications. Hence, the method appears to be a very useful engineering tool which should be maintained. Consequently, the computer programs have been consolidated into an easily used design package which can be supplied to other facilities. Final documentation of this design package is currently underway.
(*h*) **Development and Application of a Lifting-Surface Design Method for Counter-Rotating Propellers,** D. M. Nelson, *NUC TP 326*, Nov. 1972.
Two Computer Programs for Use in Designing Wake-Adapted Counter-Rotating Propellers, A User's Manual, D. M. Nelson, *NUC TN 1316*, May 1974.

342-07221-160-20

FLOW NOISE WITH POLYMERS

(*b*) Office of Naval Research.
(*c*) J. M. Caraher, Code 2542.
(*d*) Experimental, basic research.
(*e*) Study the effect of dissolved polymers on wall pressure fluctuations in a pipe.
(*f*) Completed.
(*g*) Measurements were made of wall pressure fluctuations at the inside wall of a pipe when flowing water and water solutions of Polyox WSR-301 were in the pipe. The addition of Polyox to the water at concentrations of 100 and 200 weight parts per million resulted in reduction in the pressure spectral density level as high as five to six dB for Strouhal numbers between five and 40 where the Strouhal number is circular frequency times pipe radius divided by the pipe center-line velocity. No effect was noticed for Strouhal numbers between 40 and 200.

342-09445-250-00

VELOCITY PROFILES IN POLYMER FLOWS

(*c*) Dr. M. M. Reischman, Code 2542.
(*d*) Experimental, basic research.
(*e*) Accurately measure the mean and fluctuating components of the stream-wise velocity of drag-reducing flows in a fully-developed, two-dimensional channel flow. The purpose was to make measurements which would be sufficient to describe the mean turbulent transport of momentum and hence the mean velocity profile; test theoretical models; and make inferences about the drag-reduction mechanism. This was accomplished by making laser Doppler anemometer measurements in a turbulent channel flow of a dilute polymer solution. Measurements were also made in water to establish the "standard" character of the channel and to establish the accuracy of the laser anemometer. The laser anemometer was operated in the individual realization mode. Velocity measurements were made using three polymers, Separan AP-273, Magnifloc 837-A and Polyox WSR-301, and at several Reynolds numbers. The flow conditions were varied to yield drag reductions ranging from 24 percent to 40 percent. The shear stress was calculated using the slope of the velocity profile near the wall. The polymer concentration was held constant at 100 wppm.
(*f*) Completed.
(*g*) The Cess model for eddy diffusivity was incorporated into a technique which allows predictions of both the mean velocity profile and the eddy diffusivity. The predictions are in good agreement with the experimental data. The eddy diffusivity is lower than that for a comparable solvent flow. The methods previously proposed to predict the mean velocity profile shift, ΔB, were found to be inadequate when the polymer species and the drag reduction were varied. The Cess model procedure used here predicts ΔB quite well.
The near-wall ($y^+ < 10$) mean velocity data for drag-reducing flows is similar to that of solvent flows. There exists no evidence of a thickened viscous sublayer. The effect of the polymer additives is to redistribute the turbulent motion into a broader buffer region and to decrease the turbulent intensity when the solvent and drag-reducing flows are compared at equal Reynolds numbers.
(*h*) **Laser Anemometer Measurements in Drag-Reducing Channel Flows,** M. M. Reishchman, W. G. Tiederman, *J. Fluid Mech.*, Sept. 1974.

342-09446-250-00

FLOW VISUALIZATION OF THE NEAR-WALL REGION IN A DRAG-REDUCING CHANNEL FLOW

(*c*) Dr. George L. Donohue, Head, Fluid Mechanics Branch, Code 2542.
(*d*) Experimental, basic research; Doctoral thesis.
(*e*) Determine whether the addition of drag-reducing macromolecules alters the structure of the viscous sublayer and thereby modifies the production of kinetic energy in turbulent wall flows. This was accomplished by visualizing the near-wall region of a fully developed two-dimensional channel flow. Motion pictures were taken of dye injected into the near-wall region. Both water and a dilute drag-reducing polyethylene oxide-FRA solution were used as working fluids. The motion pictures were analyzed to determine the spanwise spacing and the bursting rate of low-speed streaks that are characteristic of the viscous sublayer. The amount of drag reduction was established from pressure-drop measurements in pipe flows and a correlation that is independent of hydraulic diameter.
(*f*) Completed.
(*g*) The data show that the time between bursts for an individual streak in a drag-reducing flow has the value for a water flow at the reduced wall shear. However, both the physical and the non-dimensional streak spacing is significantly increased in the drag-reducing flows and thus the spatially averaged bursting rate is decreased. This evidence strongly suggests that the dilute polymer solution decreases the production of turbulent kinetic energy by inhibiting the formation of lowspeed streaks. A tentative explanation for this behavior which is based upon the solution's high resistance to elongational strains and vortex stretching is offered.
(*h*) **Flow Visualization of the Near-Wall Region in a Drag-Reducing Channel Flow,** G. L. Donohue, W. G. Tiederman, M. M. Reischman, *J. Fluid Mech.* **56**, 3, pp. 559-575, Dec. 1972.

342-09447-700-00

TURBULENCE MEASUREMENTS WITH A LASER ANEMOMETER MEASURING INDIVIDUAL REALIZATIONS

(*c*) Dr. George L. Donohue, Head, Fluid Mechanics Branch, Code 2542.
(*d*) Experimental, applied research; Doctoral thesis.

(*e*) A laser Doppler anemometer system is described which operates with a noncontinuous signal and measures the velocity of individual scattering centers. Histograms of the instantaneous individual velocity realizations provide accurate and unambiguous estimates of the mean velocity and rms fluctuation velocity in regions of intense turbulence levels. Measurements are presented for a fully developed two-dimensional water channel and a deflected jet of air.
(*f*) Completed.
(*g*) See (e).
(*h*) **Turbulence Measurements With a Laser Anemometer Measuring Individual Realizations,** G. L. Donohue, D. K. McLaughlin, W. G. Tiederman, *Phys. Fluids* **15,** 11, pp. 1920-1926, Nov. 1972.

342-09448-870-22

HARBOR POLLUTION FROM LARGE SHIPS

(*b*) Naval Ship Systems Command.
(*c*) Dr. J. W. Hoyt, Code 2501.
(*d*) Experimental applied research.
(*e*) Develop data to ascertain the magnitude of the sewage pollution problem arising from Navy ships anchored in or moving through a harbor, with particular reference to amphibious training exercises in which large numbers of personnel may be brought to near-shore areas for relatively short times.
(*f*) Completed.
(*g*) A number of releases of dyed sewage were made in Wilson Cove Harbor of San Clemente Island at rates corresponding to those at which sewage would be discharged by amphibious task forces of from 500 to 10,000 men. The movement of the sewage was traced by photography, bacterial counts, dye, and BOD measurements in the surrounding water and on the shoreline. The results show that the diffusion (rate of spreading) of the sewage was much lower than that predicted from open-ocean data, and hence Navy ships can stay in a small harbor, such as Wilson Cove, much longer than originally anticipated without danger of sewage contamination of the shoreline. An operational guidance chart was constructed indicating those times and minimum distances for a given manning level of a task force that would prevent contamination of the shore.
(*h*) **Harbor Pollution From Large Ships,** G. L. Donohue, J. W. Hoyt, in *Flow Studies in Air and Water Pollution*, ASME, N. Y., p. 135, 1973.
Harbor Pollution From Large Ships, G. L. Donohue, J. W. Hoyt, *NUC TP 368*, Oct. 1973.
Harbor Pollution From Large Ships, G. L. Donohue, J. W. Hoyt, *Intl. Shipbuilding Progress* **21,** p. 289, Oct. 1974.

342-09449-250-20

FRICTION-REDUCING SUSPENSIONS

(*b*) Office of Naval Research.
(*c*) Dr. J. W. Hoyt, Naval Undersea Center, Code 2501.
(*d*) Experimental basic research.
(*e*) Fibers of asbestos, glass, and acrylic were found to greatly reduce the turbulent flow friction of aqueous suspending fluids. Pipe-flow and rotating-disk experiments show that fibers having the smallest diameter, and substantial length-to-diameter ratio gave the most friction reduction at the smallest weight concentration of fiber. An asbestos fiber gave 65 percent friction reduction in a small pipe-flow apparatus and 48 percent in the rotating-disk equipment (both being the maxima obtainable in the devices) at a suspension concentration of 500 ppm.
(*g*) See (e).
(*h*) **Turbulent Flow of Drag-Reducing Suspension,** J. W. Hoyt, Naval Undersea Center, *TP 299*, July 1972.

342-09450-250-20

WATER JET PHOTOGRAPHY

(*b*) Office of Naval Research.
(*c*) Dr. J. W. Hoyt, Naval Undersea Center, Code 2501.
(*d*) Experimental basic research.
(*e*) Jets of water and of poly(ethylene oxide) solutions discharging in air were photographed using a novel image-motion compensating camera. Spray droplet formation is inhibited by low concentration polymer solutions. The effect of the polymer is to reduce, dampen, or eliminate small-scale surface disturbances in the jet, while not reducing but even amplifying larger scale motions. The initial laminar zone present in the jet efflux with water is eliminated with trace quantities of polymer. When substantial quantities of polymer are present (200 ppm), the jet breakup is accompanied by filament formation linking all the drops together.
(*g*) See (e).
(*h*) **The Structure of Jets of Water and Polymer Solution in Air,** J. W. Hoyt, J. J. Taylor, C. D. Runge, *J. Fluid Mech.* **63,** 4, pp. 735-640, 1974.
A Photographic Study of Polymer Solution Jets in Air, J. W. Hoyt, J. J. Taylor, presented *BHRA Intl. Conf. on Drag Reduction*, Cambridge, England, Sept. 1974.

342-09451-250-22

COMPLIANT SURFACE STUDIES

(*b*) Naval Research Laboratory.
(*c*) Dr. M. M. Reischman, Code 2542.
(*d*) Experimental, basic research.
(*e*) An experimental investigation of the interaction of flat plate compliant surfaces and adjacent shear flows was conducted using photographic techniques. A recirculating water tunnel at the U. S. Naval Academy was chosen as the experimental testbed. Initial measurements were made of the gross flow characteristics of the tunnel. The flow rate was measured and calibrated; the two-dimensionality of the flow was verified; and the free stream turbulence level was determined (less than two percent). A flat plate containing a small area for the compliant surface was constructed and placed in the center of the water tunnel flow field. The compliant surfaces were polyvinyl chloride plastisols with a seven percent resin content. Photographs of the compliant surface configuration were taken over a wide range of tunnel freestream velocities. Movies of the dynamic behavior of the compliant surface were also made. Reference measurements of the compliant surface behavior in the more familiar rotating disc geometry were made coincidently.
(*g*) The results show that the onset parameter previously established by Hansen and Hunston was found to be verified in the two-dimensional flat plate geometry. The results have further shown that the wavelike structure of the compliant surface-flow interaction is not stationary in the two-dimensional geometry. Movies indicate that the waves move uniformly downstream at approximately 0.005 times the free-stream velocity. Further analysis of the still photographs has shown the wavelength of the surface disturbance to be slightly greater (1.4 to 1.6 times) in the flat plate geometry. The wave structure on the flat plate is much more random than on the disk geometry, in terms of width, placement, etc. Lastly, from preliminary observations, the wave height for the two flow geometries appears qualitively similar.

342-09452-220-13

HYDROCYCLONES FOR DREDGE SPOIL

(*b*) U. S. Army Corps of Engineers, Waterways Experiment Station.
(*c*) Dr. M. M. Reischman, Code 2542.
(*d*) Experimental, basic research.
(*e*) Experimentally determine the feasibility of using hydrocyclone separators for the concentration, clarification, and classification of a dredge spoil. Six dredge spoil samples (supplied by the United States Army Corps of Engineers), two clay slurries, and one sand were used to determine the effect of particle size, viscosity of the fluid, and inlet solids concentration on the effectiveness of 10-gpm hydrocyclones. While the clarification and concentration performance of the hydrocyclones was good on low solids content clay slurries, the performance ranged from below

average to poor on the spoil samples. The poor capability of the separators to clarify and concentrate these spoils was due to a combination of high solids content, small particle sizes, and highly pseudoplastic behavior of the spoils. The high solids content affects clarification more than it does concentration, and thus, hydrocyclones may be reasonably effective concentrators for the low solids content spoils. Meanwhile, the hydrocyclone proved very successful at recovering sand from the full range of spoils.

(*f*) Completed.

(*g*) See (*e*).

(*h*) **Feasibility of Hydrocyclones for Dredge Spoil,** W. G. Tiederman, M. M. Reischman, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **100,** WW4, *Proc. Paper 10953*, pp. 361-376, Nov. 1974.

NAVAL UNDERWATER SYSTEMS CENTER, NEW LONDON LABORATORY, New London, Conn. 06320. Capt. M. C. McFarland, Commanding Officer; H. E. Nash, Technical Director.

343-09453-160-22

FLOW-INDUCED NOISE PREDICTIONS FOR AN IDEALIZED SONAR DOME

(*b*) Chief of Naval Material, Dr. J. H. Huth, DLP/MAT 03L4.

(*c*) Russell Christman, Mechanical Engineer.

(*d*) Theoretical; basic research.

(*e*) The characteristics of the pressure field generated by infinite and finite plates excited by turbulent boundary layer flow in the presence of heavy fluid loading are examined.

(*f*) Completed.

(*g*) In estimating flow-induced noise, the effects of the fluid environment on the plate are important and represent forces to the plate that may be interpreted as both inertial and resistive forces. Not including all the effects of the fluid leads to substantial errors in the estimation of flow-induced noise. A comparison of finite and infinite plate pressure spectra reveals that only at the surface of the plate does the infinite plate provide a good estimate of the finite plate pressure.

(*h*) **Pressure Radiated by Turbulence-Excited Finite and Infinite Water-Loaded Plates,** R. A. Christman, *NUSC Tech. Rept. No. 4573*, Oct. 4, 1973.

343-09454-240-29

FLUID FINITE ELEMENT DEVELOPMENT

(*b*) Department of Defense.

(*c*) A. D. Carlson, Engineering Mechanics.

(*d*) Applied research.

(*e*) Calculate the response of a structure in a fluid subjected to pressure pulses.

(*g*) Reasonable correlation between analysis and several experiments.

NAVAL UNDERWATER SYSTEMS CENTER, NEWPORT LABORATORY, Newport, R. I. 02840. Capt. M. C. McFarland, Commanding Officer; H. E. Nash, Technical Director.

344-09455-250-00

DRAG REDUCTION MECHANISM; POLYSTYRENE

(*c*) R. H. Nadolink, Project Engineer.

(*d*) Experimental; basic research.

(*e*) Using special ultra high molecular weight, nearly monodisperse, polystyrene, conduct experiments to elucidate the mechanism of polymeric friction reduction. Since polystyrene is easily characterized and many solvent/non-solvent systems are available, although they are non-aqueous, and a family of molecular weights available, meaningful experiments can be conducted with clear results. Also, different solvent-temperature reactions can be tested. This is clearly opposed to experiments conducted with commercially available poorly characterized bulk polymers of broad molecular weight distribution and limited solvent systems.

(*h*) **Friction Reduction in Dilute Solutions of Polystyrene: Part 1,** R. H. Nadolink, *NUSC TR 4422*. May be obtained by contacting R. H. Nadolink, NUSC, Newport Lab., Bldg. 148.

344-09456-250-22

POLYMER NOISE-DRAG REDUCTION: ADVANCED APPLICATIONS

(*b*) Naval Sea Systems Command.

(*c*) M. Cincotta, Chemical Engineer.

(*d*) Experimental; basic and applied research.

(*e*) Construct a facility which will incorporate a laser Doppler velocimeter and a special rectangular test section to determine boundary layer diffusion; boundary layer polymeric hydration; turbulent intensity effects of polymers; and controlling factors in boundary layer hydration of polymers. These results should begin to describe the mechanism of polymeric friction reduction and allow for tailoring of polymer ejection schemes for specific applications.

(*g*) Facility has been constructed and debugged. Calibration experiments to begin soon.

344-09457-250-00

EFFECT OF COMPLIANT LAYER ON FLOW NOISE

(*c*) Richard N. Brown, Applied Hydromechanics Branch, Weapons Department.

(*d*) Experimental and theoretical; applied research.

(*e*) The effects of a compliant layer on the turbulent boundary layer wall pressure fluctuation spectrum and radiated noise spectrum is studied using a submerged, rotating cylinder facility. To the aluminum cylinder are attached 1/16 in. to 1/4 in. thick rubber and other viscoelastic layers. The cylinder is rotated at speeds up to 100 fps and wall pressures, cylinder wall accelerations, radiated noise, and drag coefficients are measured. Theoretical estimates of the compliant layer-turbulent boundary layer interaction are being developed. From this study, a more complete description of the drag reducing and quieting properties of compliant layers will evolve.

(*g*) The submerged, rotating cylinder facility has been modified to provide smooth operation over all speeds and to permit on-line data analysis. Baseline data on an unlayered cylinder has been measured. Drag coefficient data has been obtained for a 1/4 in. air-filled neoprene layer, and shows a drag increase above 40 fps.

TENNESSEE VALLEY AUTHORITY, ENGINEERING LABORATORY, Drawer E, Norris, Tenn. 37828. E. Ely Driver, Laboratory Director.

345-07080-340-00

RACCOON MOUNTAIN PUMPED-STORAGE PROJECT – HYDRAULIC TRANSIENT STUDIES

(*d*) Applied research; for design.

(*e*) Tentative agreement with Engineering Design on wicket-gate opening and closing times initiated a series of computer runs for various machine operating conditions and pool elevations.

(*f*) Completed.

(*g*) A report was issued presenting the results of waterhammer and surge computations for the range of operating conditions requested by Design.

345-07083-870-00

BROWNS FERRY NUCLEAR PLANT – CONDENSER-WATER THERMAL DIFFUSION IN A THREE-DIMENSIONAL MODEL

(*d*) Applied research; for design.
(*e*) Condenser cooling water is mixed with the flow in Wheeler Reservoir by means of three diffuser pipes. Flows through Wheeler Reservoir are controlled by two hydro projects, Wheeler and Guntersville Dams. These projects, operated for peaking power requirement purposes, cause highly variable flows in Wheeler Reservoir. A distorted scale model, supplied with inflows of heated and cooled water to simulate the condensate cooling problem, is being used to develop water temperature information.
(*g*) Data from the field will be taken, with units one and two operating, so that comparisons may be made with model study results.

345-08562-340-00

RACCOON MOUNTAIN PUMPED-STORAGE PROJECT, LOWER RESERVOIR TRASHRACK VELOCITY DISTRIBUTION STUDIES

(*d*) Applied research; for design.
(*e*) Additional tests were conducted using the 1:40 scale model of the Raccoon Mountain lower reservoir inlet-outlet to improve the distribution of flows approaching the trashrack section during the generating cycle and to design an anti-vortex baffle wall for the pumping mode.
(*f*) Completed.
(*g*) Structural modifications which showed considerable improvement in simulated operation in the model were recommended to the Office of Design and Construction.

345-08569-350-00

NORMANDY DAM

(*d*) Applied research; for design.
(*e*) Using a 1:100 scale model of this water-control project, tests were conducted to develop a spillway, spillway apron and training wall design which would provide for a satisfactory performance for this structure over the anticipated range of operating conditions.
(*f*) Completed.
(*g*) A proposed design was finalized and adopted by Engineering Design.

345-08570-860-00

FORT PATRICK HENRY AERATION STUDY

(*d*) Field investigation; experimental.
(*e*) Water released from Fort Patrick Henry Dam into the South Fork Holston River usually has a low dissolved oxygen (DO) concentration during the summer and fall months. Over the last 10 years the average yearly minimum DO concentration was 1.8 mg/l in water sampled from the scroll case, below 6 mg/l (desirable concentration for cold water fisheries) an average of 191 days each year. Additionally, these low DO levels intensify the stream pollution problem downstream from the dam.
Studies of possible alternative reaeration methods indicate that molecular oxygen gas injection into the turbine releases is probably the most practicable approach to correct the low DO problem at the Fort Patrick Henry project. With this approach, small oxygen bubbles are injected into the reservoir near the bottom through a battery of porous diffusers located immediately upstream from the turbine intakes. The oxygen is dissolved in the water as the bubbles rise and follow the water currents through the turbines.
A research project is being conducted to determine the suitability of available commercial diffusers and to develop a deployment scheme which will optimize oxygenation efficiency. This research is necessary because little information is avaialble for the design of such oxygenation systems on a large scale.

(*g*) Preliminary evaluations of diffuser design and placement have been made.

345-08571-870-00

BROWNS FERRY NUCLEAR PLANT – COOLING TOWERS

(*d*) Applied research; for design.
(*e*) A 1:39.4 scale model of the return channel for the cooling towers at Browns Ferry was used to develop a workable gate system which would effectively handle flows during the periods when the cooling tower system would be required to provide total cooling water for the plant's condensate process and when the cooling tower system might be used in a helper mode with a portion of the plant's requirement of condensate cooling water being taken from Wheeler Reservoir.
(*f*) Completed.
(*g*) Design of three gate structures and downstream appurtenances were developed from model studies to insure a satisfactorily performing cooling tower return channel system.

345-09458-870-00

WIDOWS CREEK STREAM PLANT SULPHUR DIOXIDE SCRUBBER

(*d*) Applied research; for design.
(*e*) Air and water representing combustion gases and limestone slurry are being used in a 1:16 scale model of a sulphur dioxide scrubber for the Widows Creek Steam Plant to develop design information on the two-phase flow problems. A major modeling problem, the determination of proper scaling of the water injection phase, is being studied at prototype and 1:2 scale.
(*g*) Interim results indicate a guide-vane system producing satisfactory velocity distribution in the model has been achieved.

345-09459-350-00

COLUMBIA DAM SPILLWAY STRUCTURE STUDY

(*d*) Applied research; for design.
(*e*) Scour studies and spillway apron performance tests on the 1:80 scale model were essentially completed. Columbia Dam is a five-gated water control structure which is under construction on the Duck River.
(*g*) A proposed structure design has been accepted by the Division of Engineering Design. Further tests will be conducted on the model to develop information on water profiles and wave heights.

345-09460-340-00

RACCOON MOUNTAIN PUMPED-STORAGE PROJECT, HYDRAULIC TRANSIENT STUDIES, NUMERICAL MODEL

(*d*) Applied research; for design.
(*e*) A numerical model was used to develop information for estimating the effects of changes in the tunnel system at Raccoon Mountain due to variations in mode of operations. A change from one steady-state to another such as due to turbine load acceptance, turbine load rejection or pump power loss would subject the tunnel system to transient pressures and produce fluid mass oscillations in the surge tank.
(*f*) Completed.
(*h*) A monograph delineating the two numerical schemes which can be used to describe this type of transient flow behavior, the method of characteristics and the implicit method, is being prepared.

345-09461-870-00

THERMAL PLUME SURVEYS AT THERMAL POWER PLANTS

(*d*) Field investigation; for operation.
(*e*) Field studies are being conducted to define the thermal regime of water bodies receiving condenser cooling water

from TVA power plants. Data are collected by means of airborne infrared remote sensing, fixed monitors and boat surveys. A specially instrumented boat was designed to obtain accurate position and temperature data.

(*h*) **Infrared Water Temperature Surveys,** P. J. Ryan, K. D. Stolzenbach, *Proc. XVth Congr. Intl. Assoc. Hydraul. Res.* **2,** Istanbul, Turkey, 1973.
The Tennessee Valley Authority's Program for Monitoring Water Temperatures in the Vicinity of Thermal Power Plants, E. E. Driver, W. R. Waldrop, presented *XVIth Congr. Intl. Assoc. Hydraul. Res.*, Sao Paulo, Brazil, July 1975.

TENNESSEE VALLEY AUTHORITY, HYDRAULIC DATA BRANCH, Knoxville, Tenn. 37902. Mr. Claude H. Smith, Branch Chief.

346-0261W-810-00

PINE TREE BRANCH WATERSHED

For summary, see Water Resources Research Catalog **6,** 2.1304.

346-00765-810-00

EVAPORATION IN THE TENNESSEE BASIN

(*d*) Field investigation; applied research.
(*e*) To provide data for estimating reservoir losses and derive a general rule, applicable to the Basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.
(*h*) Results published in monthly and annual bulletins, *Precipitation in Tennessee River Basin* (Project 00768).

346-00768-810-00

PRECIPITATION IN TENNESSEE RIVER BASIN

(*d*) Field investigation; basic research.
(*e*) A comprehensive study of rainfall and other weather phenomena for purposes of water dispatching and improvements in water control; storm studies as related to maximum precipitation, rainfall-runoff, spillway design and operation, etc.
(*h*) Monthly and annual bulletins, *Precipitation in Tennessee River Basin.*

346-00769-860-00

RESERVOIR AND STREAM TEMPERATURES

(*d*) Field investigation; basic research.
(*e*) Study of water utilization and water movement as concerns industrial and steam plant locations and stream pollution. Variations in temperature from surface to bottom in selected reservoirs are determined by soundings, and by continuous recording gages in selected natural streams. Periodic observations are made at gaging stations.

346-00771-350-00

GALLERY DRAINAGE IN LARGE DRAINS

(*d*) Field investigations; design.
(*e*) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

346-00780-820-00

PERIODIC EVALUATION OF GROUNDWATER STORAGE

(*d*) Theoretical; operation.
(*e*) By analysis of current records of stream discharge, the volumes of runoff in groundwater and channel storage are determined for use in operation of multi-purpose reservoirs.
(*g*) Results reported weekly within the organization.
(*h*) Unpublished Paper – **Uncontrolled Storage in the Tennessee Valley,** presented *44th Ann. Mtg. AGU*, Apr. 1963.

346-00785-350-00

SEDIMENTATION OF EXISTING RESERVOIRS

(*d*) Field investigation; design and operation.
(*e*) Selected ranges in reservoirs are probed and sounded, volumetric samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of down-stream reservoirs, and probable sedimentation in future reservoirs.
(*h*) **Sedimentation in TVA Reservoirs,** *Rept. No. 0-6693*, TVA, Feb. 1968.

346-07089-810-00

WATERSHED STUDIES OF FERTILIZER MOVEMENT

(*d*) Field investigation; basic research.
(*e*) The movement of nutrients in runoff from both fertilized and unfertilized forested and agricultural watersheds is being studied on six watersheds in the Tennessee Valley. These include five watersheds previously instrumented for other purposes and now modified to permit sampling for water-quality parameters.
(*f*) Fertilizer applications were made following calibration periods on two of the three agricultural watersheds. Forage samples were obtained to determine uptake of nutrients by pasture grasses. Proportional streamflow sampling is accomplished by mechanical splitter-type samplers or automatic pumping samplers. Subsequent fertilization on forested watersheds will be coordinated with management programs.
(*g*) Only preliminary results are available. Findings will be published in technical journals and project reports.
(*h*) **Nutrient Losses from Small Watersheds,** V. J. Kilmer, R. T. Joyce, presented *Irrig. and Drainage Div. Specialty Conf., ASCE*, Miami Beach, Fla., Nov. 1970.
Fertilizer Use in Relation to Water Quality with Special Reference to the Southeastern United States, V. J. Kilmer, R. T. Joyce, July 1971.

346-08574-810-00

EFFECTS OF URBANIZATION UPON THE QUALITY AND QUANTITY OF STREAMFLOW

(*d*) Field investigation; basic research.
(*e*) Four watersheds in Knoxville with different types of urban development have been instrumented to provide rainfall, runoff, and water-quality measurements. Data will be used to assess the effect of different levels of urbanization upon water quantity and quality, and to develop techniques to predict the impact of urbanization upon these parameters.
(*f*) Data collection and manual sampling began in the spring of 1971. An automatic pumping sampler will be used at each of the sites to provide representative samples.
(*g*) Results will be reported in appropriate technical journals and project reports.

TENNESSEE VALLEY AUTHORITY, WATER RESOURCES MANAGEMENT METHODS STAFF, Knoxville, Tenn. 37902. Walter O. Wunderlich, Supervisor.

347-08575-800-00

DEVELOPMENT OF WATER RESOURCES MANAGEMENT METHODS

(*d*) Theoretical; applied research.
(*e*) The project will develop for the Tennessee River system comprehensive procedures which will allow current evaluation and consideration of all essential objectives, such as navigation, flood control, power production, water quality management, water supply and recreation. The methods will be used as day-to-day decision aids for TVA's water resource planning and management activities. They will expand the present decision-making process by

using more comprehensive and automated procedures which can respond to the steadily increasing complexities of water quantity and quality management.

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U. S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, Office of Research, HRS-42, Washington, D. C. 20590. Charles F. Scheffey, Director of Research.

348-08577-360-00

ENERGY DISSIPATORS FOR CULVERTS AND HIGHWAY DRAINAGE STRUCTURES

(*c*) J. S. Jones.
(*d*) Experimental, applied research.
(*e*) Investigation of various schemes of dissipating the erosive force of water in highway drainage structures is underway. The combined effort of personnel from several FHwA offices will prepare a design manual presenting virtually every dissipation method known and some just recently conceived. Laboratory testing of transverse roughness bars within the culvert itself has recently been completed. A field survey of dissipators being used by State Highway Departments is being made.

348-09462-370-00

HYDRAULIC PERFORMANCE OF GRATE INLETS

(*c*) Dr. D. C. Woo.
(*d*) Experimental; applied.
(*f*) Complete.
(*g*) Hydraulic efficiencies of two new designs of potentially bicycle-safe grate inlets were obtained and compared with those of the two most popular existing designs: the parallel-bar grate (hydraulically most efficient) and the transverse-bar grate (hydraulically inefficient).
(*h*) **Hydraulic Characteristics of Two Bicycle-Safe Grate Inlet Designs,** *FHwA R&D Report*, Nov. 1974.

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PROJECT REPORTS FROM CANADIAN LABORATORIES

ACRES CONSULTING SERVICES LIMITED, 5259 Dorchester Road, Niagara Falls, Ontario L2E 6W1, Canada. J. E. Cowley, Head, Hydraulic Department.

400-08156-340-75

NINE-MILE POINT THERMAL MODEL STUDY

(*b*) Quirk, Lawler and Matusky, Engineers.
(*d*) Experimental, for design purposes.
(*e*) Construction and testing of a thermal hydraulic model to study thermal discharge into Lake Ontario by cooling water from the Niagara Mohawk Power Corporation Nine-Mile No. 1 and No. 2 units. The 1:80 undistorted scale model covered a lake area 8,800 feet by 14,000 feet. Automated data acquisition and processing by computer was utilized during testing.
(*f*) Study complete, report submitted to client.
(*g*) The study demonstrated acceptable dispersion patterns and surface temperatures under normal operating conditions.

400-09463-330-70

GRAND ILE MARINE TERMINAL SITE HYDROGRAPHIC SURVEY

(*b*) CECOP Company Limited.
(*d*) Experimental.
(*e*) The realistic assessment of a marine terminal site required field survey of hydrographic conditions along the approach route between Cabot Strait and Grand Ile. Detailed sounding information was obtained in the Kamouraska Basin, and an ice reconnaissance was made. Currents were also studied at various anchor stations at three depths to determine the effects of tidal action.
(*f*) Study complete, report submitted to client.
(*g*) Charts of channel dimensions and depths were produced along with plots of tidal fluctuations and induced currents. Wave height frequency diagrams were also produced.

400-09464-330-70

GRAND ILE MARINE TERMINAL – ICE MODEL STUDY

(*b*) CECOP Company Limited.
(*d*) Experimental, for design purposes.
(*e*) A 1:200-scale model was used to evaluate problems due to moving ice at the terminal site, and to measure changes in river currents due to terminal structures and moored vessels. The model was also used to assess the effectiveness of ice protection measures. The prototype area covered by the model was 1.3 by 2.6 miles. Fans adjacent to the model were used to simulate onshore wind effects on ice drift and pileup.
(*f*) Study complete, report submitted to client.
(*g*) As a result of the model studies the originally proposed ice protection breakwaters were replaced by skimmer ice booms due to more favorable effects on current patterns.

400-09465-330-70

GRAND ILE MARINE TERMINAL – ICE STUDIES

(*b*) CECOP Company Limited.
(*d*) Experimental, for design purposes.
(*e*) To assess probable ice effects on marine terminal operations, historical ice observations, detailed site studies and a hydraulic model were utilized to develop design criteria. Aerial reconnaissance of ice in the terminal area was undertaken to determine ice type, formation and movement patterns.
(*f*) Study complete, report submitted to client.
(*g*) Charts of ice occurrence and effects on vessel movement were produced along with a statistical appreciation of trip delays due to ice.

400-09466-330-90

DETERMINATION OF ICE FORCES ON A CHANNEL MARKING PIER

(*b*) Government of Canada, Ministry of Tranport.
(*d*) Experimental.
(*e*) Instrumentation to measure total ice forces against a pier was designed and installed. Pressure sensing panels relay data to analog computers and oscillograph at the pier and summary data is telemetered by radio-telex link to a control station. The purpose of the project is to assess the adequacy of current design loads used in construction.
(*f*) Instrumentation complete, data collection in progress.
(*g*) During winter 1973-74, a power failure limited the amount of data collected. Summary review of results indicated the possibility of very high ice loads. A backup power system was installed during 1974 and further data collection will continue during the winter 1974-75.

400-09467-340-96

ARNPRIOR GENERATING STATION RIVER ICE OBSERVATIONS

(*b*) Ontario Hydro.
(*d*) Experimental.
(*e*) The natural mechanism of ice formation and breakup on the Madawaska River at Arnprior, Ontario, was investigated to provide insight into likely changes due to generating station construction. By use of a hovercraft ice thickness measurements were taken at dozens of locations over a two-mile reach of the river. These observations were correlated with wind, air temperature and water temperature data.
(*f*) Study complete, report submitted to client.
(*g*) Maps of typical ice formations were produced indicating potential ice jam zones. Results were used to guide construction activity, as a record of pre-construction conditions, and as an indication of likely ice conditions during future operation of the hydro-electric generating station.

400-09468-340-75

PERRY THERMAL MODEL STUDY

(*b*) NUS Corporation.
(*d*) Experimental, for design purposes.
(*e*) Design, construction and testing of a thermal hydraulic model to study cooling water discharge into Lake Erie from proposed Perry Nuclear Power Plant (2,468 Mw) of Cleveland Electric Illuminating Company. The 1:75 undistorted scale model covered a prototype lake area 6,500 feet by 8,000 feet. Representative ambient currents, including onshore currents, were tested. Automated data acquisition and processing by computer were utilized during testing.
(*f*) Study complete, report submitted to client.

(g) The study demonstrated acceptable dispersion patterns and surface temperatures under normal operating conditions.

400-09469-430-96

ARNPRIOR GENERATING STATION WAVE RUNUP AND RIPRAP STUDIES

(b) Ontario Hydro.
(d) Experimental, for design purposes.
(e) A 1:100 scale model of an auxiliary dike was tested to determine the minimum stable stone size for wave protection. The dike configuration included upstream underwater berms at various elevations extending a number of hundreds of feet from the main structure. To assess the effect on the maximum height of incident waves, riprap size requirements and areal extent of protection required, scale waves of various probabilities were tested.
(f) Study complete.
(g) The berms were shown to have a significant effect in reducing incident wave height. However, the leading edge of each berm required riprap protection against erosion. Based on test results final stone sizes and limits of protection were selected for both the berms and the upstream face of the main dike structure.

400-09470-340-96

ARNPRIOR GENERATING STATION TAILRACE WEIR MODEL

(b) Ontario Hydro.
(d) Experimental, for design purposes.
(e) A 1:50 scale model of a tailrace channel overflow weir was used to assess water levels to be expected, current patterns upstream and downstream and confirm cofferdam heights for construction staging. The area reproduced was about 1,200 feet upstream and downstream from the weir by 1,400 feet wide. Flows up to the 10,000-year return period flood were tested in the fixed bed model.
(f) Study complete, report submitted to client.
(g) The design crest length of 1,050 feet for the new weir was confirmed to give the minimal upstream water level fluctuation desired for daily flow variations. Satisfactory current velocities and patterns were observed. The horseshoe plan configuration of the structure was confirmed as satisfactory since it provided the desired long crest length while avoiding the removal of an island park in the center of the river at the weir site. Flow up to 51,000 cfs were tested.

400-09471-360-96

ARNPRIOR GENERATING STATION SLUICEWAY MODEL

(b) Ontario Hydro.
(d) Experimental, for design purposes.
(e) A 1:56.25 scale model of a 65-foot head hydro power dam and sluiceway was used to develop an effective and economical stilling basin design. The 3-D model included an area 1,200 feet upstream and downstream from the sluiceway. Flows up to the 10,000-year return period flood were tested in both fixed bed and mobile bed configurations.
(f) Study complete, report submitted to client.
(g) A stilling basin 92 feet wide by 50 feet long with its floor set 15 feet below the downstream channel bed was found effective for flows up to 42,000 cfs. The basin contains steel clad baffle blocks 10 feet high by 8 feet wide. Maximum energy dissipation with acceptable turbulence was achieved. Better performance was obtained at all flows with equal openings on all three gates. Considerable prototype savings resulted in comparison to the anticipated costs of a conventional stilling basin design.

400-09472-330-20

ST. MARY'S RIVER ICE MODEL

(b) U. S. Corps of Engineers.
(c) Dr. J. Hayden, Acres American Inc., Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, N. Y. 14202.
(d) Experimental, for design purposes.
(e) An undistorted 1:120 scale model of a portion of the St. Mary's River has been modeled to assess alternative means of ice control to assist winter navigation. The model covers a prototype length of 22,320 feet, and reproduces existing topography and underwater contours.
(f) Study in progress, model under construction.
(g) Theoretical analyses are currently underway, along with laboratory development of a model ice material. Model construction is underway with testing to be carried out during 1975.

400-09473-340-73

WIND TUNNEL MODEL OF ATMOSPHERIC DISPERSION OF POWER PLANT EMISSIONS

(b) Consumers Power Company, Michigan.
(c) Dr. J. Hayden, Acres American Inc., Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, N. Y. 14202.
(d) Experimental.
(e) Local terrain was reproduced in a 1:400 scale model, including two power plants and other buildings. The purpose of the study was to assess how the stack configurations at the Kain and Weadock affect plume downwash. Stack discharges were modeled with scale flows of buoyant gases to simulate gas temperature with visual additive to permit photography. Ground level concentrations of emissions were estimated for various stack configurations and operating conditions.
(f) Study complete.
(g) The results of the study were presented in the form of hourly, 24 hourly and annual estimations of the ground level concentrations of the emissions.

400-09474-340-75

AIR MODEL STUDIES OF ELECTROSTATIC PRECIPITATORS FOR WABAMUM STATION, UNITS 2, 3, AND 4, CALGARY POWER LIMITED

(b) Research-Cottrell (Canada) Limited.
(c) Mr. M. J. Hobson, Executive Engineer, Acres American Inc., Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, N. Y. 14202.
(d) Experimental; design.
(e) The insertion of an electrostatic dust precipitator into the flues of an existing thermal power plant generally requires extensive and complicated duct work. The requirements of minimizing head losses in the duct work and achieving a uniform flow distribution through the precipitator to maintain a high degree of efficiency require model studies. A scale model of the precipitator and its dust collector curtains, hoppers, etc., and associated duct work was used for the study. The model was manufactured in Plexiglas with the exception of the collector curtains, which were from steel.
The study is concerned with the necessity to distribute the gas glow evenly over the collector curtains with the minimum of turbulence and head loss. In the approach duct work, space restrictions dictate short radius bends so that the placing of guide vanes and diffuser screens constitutes the main part of the program. The study also includes an investigation of the flow conditions in the duct work with particular reference to the location of possible areas of dust buildup. An anemometer with automatic traversing and plotting capabilities is employed to ensure uniformity of readings and continuous recording of the velocity profiles. 563,000 ACFM, 680°, 66 MW.
(f) Completed. Report submitted to client.

400-09475-340-70

AIR MODEL STUDIES OF ELECTROSTATIC PRECIPITATORS FOR COLESON COVE STATION, UNITS 1, 2, AND 3, NEW BRUNSWICK ELECTRIC POWER COMMISSION

(*b*) Joy Manufacturing Company (Canada) Limited.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 1,017,240 ACFM, 350°.
(*f*) Completed. Report submitted to client.

400-09476-340-70

HAYDEN STATION, UNIT 2, COLORADO UTILITIES ELECTRIC ASSOCIATION

(*b*) Wheelabrator - Frye Inc.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 1,684,000 ACFM, 695°, 250 MW.
(*f*) Study complete. Report submitted to client.

400-09477-340-75

BRANDON SHORES STATION, UNITS 1, AND 2, BALTIMORE GAS AND ELECTRIC COMPANY

(*b*) Babock and Wilcox.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 2,819,000 ACFM, 650°, 660 MW.
(*f*) Study complete. Report submitted to client.

400-09478-340-70

MAYNARD STATION, UNIT 24, IOWA PUBLIC SERVICE COMPANY

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 338,000 ACFM, 780°.
(*f*) Study complete. Report submitted to client.

400-09479-340-70

LEYLAND OLDS STATION, UNIT 2, BASIN ELECTRIC POWER CORPORATION

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 2,100,000 ACFM, 393°.
(*f*) Study complete. Report submitted to client.

400-09480-340-70

DUNKIRK STATION, UNITS 1 AND 2, NIAGARA MOHAWK POWER CORPORATION

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 270,000 ACFM, 700°.
(*f*) Study complete. Report submitted to client.

400-09481-340-70

DUNKIRK STATION, UNITS 3 AND 4, NIAGARA MOHAWK POWER CORPORATION

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 675,000 ACFM, 700°.
(*f*) Study complete. Report submitted to client.

400-09482-340-70

OSWEGO STATION, UNIT 5, NIAGARA MOHAWK POWER CORPORATION

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 2,300,000 ACFM, 400°.
(*f*) Study complete. Report submitted to client.

400-09483-340-70

WARRICK POWER PLANT, UNITS 1, 2, AND 3, ALUMINUM COMPANY OF AMERICA

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 688,000 ACFM, 710°.
(*f*) Study complete. Report submitted to client.

400-09484-340-70

GREEN BAY STATION, UNITS 8 AND 8A, WISCONSIN PUBLIC SERVICE COMPANY

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 580,000 ACFM, 350°.
(*f*) Study complete. Report submitted to client.

400-09485-340-70

1300-MW UNIT AMERICAN ELECTRIC POWER

(*b*) Wheelabrator-Frye.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 563,000 ACFM, 1300 MW.

400-09486-340-70

JADISON COUNTY STEAM PLANT, UNIT 1, MISSISSIPPI POWER

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75.
(*f*) Study complete. Report submitted to client.

400-09487-340-70

ST. CLAIR STATION, DETROIT EDISON

(*b*) Wheelabrator-Frye.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 751,000 ACFM.
(*f*) Study complete. Report submitted to client.

400-09488-340-70

ROY S. NELSON STATION, GULF STATES UTILITIES COMPANY

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 755,000 ACFM.

400-09489-340-75

WYODAK STATION, BLACK HILLS POWER AND LIGHT

(*b*) Babcock and Wilcox.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 1,812,000 ACFM.

400-09490-340-70

UNIVERSAL SLAB MILL HOT SCARFER FACILITY, JONES AND LAUGHLIN STEEL CORPORATION

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 125,000 ACFM.

400-09491-340-70

WHITING REFINERY, AMOCO OIL COMPANY

(*b*) Precipitair Pollution Control.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 298,200 ACFM, scale 1:12.

400-09492-340-70

DALE STATION, UNITS 3 AND 4, EAST KENTUCKY RURAL CO-OP

(*b*) American Standard.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 368,000 ACFM, scale 1:16.
(*f*) Study complete, report submitted to client.

400-09493-340-70

BENECIA REFINERY, CALIFORNIA, HUMBLE OIL REFINERY COMPANY

(*b*) Precipitair Pollution Control.
(*c*) See 400-09474-340-75.
(*d*) Experimental, design.
(*e*) See 400-09474-340-75. 210,000 ACFM, scale 1:12.
(*f*) Study complete, report submitted to client.

400-09494-340-70

TEXAS CITY REFINERY, TEXAS, AMOCO OIL COMPANY

(*b*) Precipitair Pollution Control.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75. 230,000 ACFM, scale 1:12.
(*f*) Study complete, report submitted to client.

400-09495-340-70

COFFEEN STATION, UNIT 1, CENTRAL ILLINOIS PUBLIC SERVICE

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) See 400-09474-340-75.
(*d*) Experimental; design.
(*e*) See 400-09474-340-75.
(*f*) Study complete. Report submitted to client.

UNIVERSITY OF ALBERTA, Department of Chemical Engineering, Edmonton T6G 2G6, Alberta, Canada. Dr. F. A. Seyer, Professor.

401-07834-070-90

FLOW OF POLYMER SOLUTIONS IN POROUS MEDIA

(*b*) National Research Council Grant.
(*d*) Experimental, Ph.D. thesis.
(*e*) Visual techniques are being used to observe the onset and behavior of viscous fingers which occur during immiscible displacement of an oil from porous media. Purpose is to develop more efficient techniques for secondary oil recovery.
(*h*) **Pressure Drop for Flow of Polymer Solution in a Model Porous Medium,** S. Vossoughi, F. A. Seyer, *CJChE*, Nov. 1974.

401-09496-120-90

VELOCITY PROFILES OF POLYMER SOLUTIONS UPSTREAM OF CONTRACTIONS

(*b*) NRC Grant.
(*d*) Experimental, Ph.D. thesis.
(*e*) Streak photographs are used to measure complete velocity field upstream of contractions. Results will be useful starting point for analysis of contraction losses and stability limits.
(*g*) Velocity profiles and observations of flow instabilities have been obtained for a variety of contraction ratios and flow rates.

UNIVERSITY OF ALBERTA, Department of Civil Engineering, Edmonton T6G 2G7, Alberta, Canada. Dr. N. Rajaratnam, Professor.

402-06630-300-90

ALBERTAN COOPERATIVE STUDIES OF RIVER REGIME

(*b*) University on NRC Grant.
(*d*) Basic and applied research.
(*e*) To aid the development of a formal quantitative inductive science of the self-adjustment of channels that form at least part of their boundaries in sediment. Steps are to collect and assess data; analyze and coordinate them in terms of an adequate "statement of case"; reduce the results to readily intelligible form, usually graphical; publicize the data, the results and their applications; and cooperate with other agencies.
(*g*) Readily available publications contain (i) the principles of statement of case, a method of coordination, and discussion of defects of data with remedies, Refs. 1-3, (ii) a collection of flume data, raw and in numerics, with punch cards, Ref. 8, (iii) a detailed analysis of these data, Ref. 9, (iv) a presentation of results for civil engineering use, Ref. 10, (v) a condensation of results from Indian irrigation canals, Ref. 4, (vi) dimensionless charts for depth and slope to coordinate river, canal and flume data, Ref. 5, (vii) simply graphed data for use of river ecologists, Ref. 6. Ref. 7 became available through membership of a cooperative program; this author records and analyzes river data obtained as part of a program by the Highway and River Engineering Division of the Alberta Research Council. To date the impact of dimensionless coordination of data appears comparable with that of the friction factor diagram on early rigid boundary hydraulics, but it requires more independent variables.
(*h*) **Mobile-Bed Fluviology,** T. Blench, 2nd ed., Univ. of Alberta Press, 1969.
Coordination in Mobile-Bed Hydraulics, T. Blench, *J. Hydraul. Div., ASCE* **95**, HY6, Proc. Paper 6884, Nov. 1969, pp. 1871-1898. Closure in **97**, HY2, Proc. Paper 1364, Feb. 1971.
Mobile Bed Hydraulics, T. Blench, *J. Hydraul. Res.* **8**, 2, 1970.
Regime Theory Design of Canals with Sand Beds, T. Blench, *J. Irrig. and Drainage Div., ASCE* **96**, IR2, Proc. Paper 7381, June 1970, pp. 205-213.
Discussion of **Sediment Transportation Mechanics, F. Hydraulic Relations for Alluvial Streams,** T. Blench, *J. Hydraul. Div., ASCE* **97**, HY11, Proc. Paper 8483, Nov. 1971, pp. 1908-1913.
Morphometric Changes, T. Blench, *Proc. Intl. Symp. on River Ecology and Impact of Man*, June 1971. Available Dept. of Natural Resources, Cornell Univ., Ithaca, N. Y.
Generalised Regime Type Analysis of Alberta Rivers, D. I. Bray, *Ph.D. Thesis*, Univ. of Alberta, 1972.
A Review of Data from Sediment Transport Experiments, R. H. Cooper, A. W. Peterson, *Rept. No. HY-1969-ST2*, Dept. of Civil Engrg., Univ. of Alberta and U. S. Dept. of Commerce, *NTIS No. PB-190233*, 1970.

A Study of Bed Material Transport Based on the Analysis of Flume Experiments, R. H. Cooper, *Ph.D. Thesis*, Univ. of Alberta, 1970.

A Critical Review of Sediment Transport Experiments, R. H. Cooper, A. W. Peterson, T. Blench, *J. Hydraul. Div., ASCE* 98, HY5, 1972.

Regime Data (Vol. I). Flume Data and Regime Basics, T. Blench (University of Alberta), D. B. Simons (Colorado State University), published for *Intl. Comm. Irrigation and Drainage*, 1974.

402-07836-220-00

FLOW IN ALLUVIAL CHANNELS

(*c*) A. W. Peterson, Professor.
(*d*) Experimental studies of sediment transport in open channels and analysis of world data.
(*e*) The behavior of flow in alluvial channels is being studied by analyzing the majority of the available experimental flume data.
(*g*) Graphical relationships have been developed for predicting flow variables. See scope of Experimental and Practical Conditions for Flow in Mobile Bed Channel, ASCE Natl. Water Resources Engrg. Mtg., Phoenix, Ariz., Jan. 1971.
(*h*) **Universal Flow Diagrams for Mobile Boundary Channels,** A. W. Peterson, *2nd Canad. Hydrotech. Conf.*, May 1975.
Design of Mobile Boundary Channels, A. W. Peterson, *Natl. Symp. on Urban Hydrology and Sediment Control*, Univ. of Kentucky, July 1975.
A Compendium of Solids Transport Data for Mobile Boundary Channels, A. W. Peterson, R. F. Howells, Environment Canada, Inland Waters Directorate, Ottawa, 1973.

402-07844-030-90

WALL WAKES

(*b*) NRC Grant.
(*d*) Analytical and experimental.
(*e*) To study and predict the characteristics of turbulent wakes growing on walls.
(*g*) On the basis of the two-layer hypothesis, plane wall wakes growing on smooth as well as rough walls have been studied. Further studies are planned on three-dimensional wall wakes.
(*h*) **An Investigation of Plane Turbulent Wall Wakes,** S. P. Rai, *Ph.D. Thesis*, Univ. Alberta, 1974.

402-07845-050-90

IMPINGING JETS

(*b*) University on NRC Grant.
(*d*) Analytical and experimental.
(*e*) To study and predict the characteristics of plane and circular turbulent jets impinging on walls.
(*g*) Studies have been made on the characteristics of circular jets impinging on smooth walls normally as well as obliquely and also for large as well as small impingement heights. Oblique impingement has been studied for plane jets and also circular jets in counter flow have been studied.
(*h*) **Turbulent Impinging Jets,** S. Beltaos, *Ph.D. Thesis*, Univ. Alberta, 1974.
Impinging Circular Turbulent Jets, S. Beltaos, N. Rajaratnam, *J. Hydraulic Div., ASCE*, Oct. 1974.
Circular Jets in an Opposing Stream, S. Beltaos, N. Rajaratnam, *Proc. Ist Canad. Hydrotech. Conf.*, Edmonton, 1973.

402-09497-060-90

HOT WATER DISCHARGES

(*b*) NRC Grant.
(*d*) Analytical and experimental.
(*e*) It is planned to study experimentally and analytically the behavior of surface discharges of hot water into lakes and rivers.
(*g*) A similarity analysis has been performed to predict the variation of the characteristic scales for low to high Richardson number. Experimental studies have also been made on discharges into lakes without any ambient current.
(*h*) **A Similarity Analysis of Buoyant Surface Jets Into Quiescent Ambients,** B. B. L. Pande, N. Rajaratnam, *Proc. IAHR Conf.*, Brazil, 1975.

402-09498-050-90

JETS IN CROSS-FLOW

(*b*) NRC Grant.
(*d*) Experimental.
(*e*) To study the characteristics of turbulent free jets and wall jets in cross-flow.
(*g*) Experiments have been made on circular free jets in cross-flow and the results are being analyzed. Experiments are in progress on circular wall jets in cross-flow.

402-09499-220-90

SCOUR BY JETS

(*d*) Experimental.
(*e*) To study and predict erosion by jets.
(*g*) Experiments have been made on scour caused by air jets on sand and light-weight plastic sphere beds.

402-09500-440-90

WATER BALANCE, COOKING LAKE MORAINE

(*b*) Inland Waters and Department of Environment, Alberta.
(*c*) Dr. J. P. Verschuren.
(*d*) Applied research.
(*e*) Determination of the cause of fluctuating lake levels by considering land use changes and climatic variability. The results of the study will indicate the quantity of water that needs be imported to obtain lake levels desirable for fish and wildlife and recreation.

402-09501-310-90

FLOOD PREDICTION ROSS RIVER AND STUART RIVER, YUKON

(*b*) Department of Indian Affairs and Northern Development.
(*c*) Dr. J. P. Verschuren.
(*d*) Applied research.
(*e*) Development of a predictive model for flooding in communities near the Ross River and the Stuart River as a function of climatic variables and preceding discharges so that an early flood warning system can be established.

ATOMIC ENERGY OF CANADA LIMITED, CHALK RIVER NUCLEAR LABORATORIES, Advance Engineering Branch, Chalk River, Ontario, Canada, KOJ 1JO. Dr. S. Y. Ahmad, Branch Head.

403-07859-130-00

FLUID-TO-FLUID MODELING OF CRITICAL HEAT FLUX AND PRESSURE DROP IN TWO-PHASE FLOW

(*c*) Dr. D. C. Groeneveld.
(*d*) Experimental and theoretical applied research study.
(*e*) Modeling is of practical importance in reducing the high cost of thermal hydraulic testing for boiling water power reactors. The working fluid water is replaced by a modeling fluid (e.g., Freon) having lower latent heat of vaporization. This reduces the test section power considerably. A generalized technique for such fluid modeling is developed from classical dimensional analysis and theory of models. Experiments complementing the analytical effort have been performed in different geometries for a large range of system parameters.
(*g*) The results of theoretical and experimental study have shown that the generalized critical heat flux modeling

technique is applicable to various Freon compounds, water, potassium and carbon dioxide. An experimental study of modeling flow stability and pressure drop in simple geometries has been completed. Further studies will deal with flow stability and subchannel mixing in complex geometries such as nuclear fuel bundles.

(*h*) **Fluid to Fluid Modeling Criteria for Two-phase Pressure Drop,** J. M. Bruce, *Atomic Energy of Canada Ltd. Rept. No. AECL-4263*, 1972.
An Experimental Investigation of Flow Instability in Freon-12, and Comparison with Water Data, J. D. Harvie, *Paper El, IChE Symp. Series No. 38*, 1974.
Fluid Modeling of Critical Heat Flux in Uniformly Heated Annuli, S. Y. Ahmad, D. C. Groeneveld, *Progress in Heat and Mass Transfer* **IV**, pp. 45-55, 1972.

BEDFORD INSTITUTE OF OCEANOGRAPHY, Atlantic Oceanographic Laboratory, Dartmouth, Nova Scotia, B2Y 4A2, Canada. Director: Wm. L. Ford.

404-07852-450-00

AIR-SEA INTERACTION

(*c*) S. D. Smith, Air-Sea Interaction Group.
(*d*) Applied and basic research. Experimental and field investigation.
(*e*) Wind stress, heat exchange, evaporation and carbon dioxide exchange at sea surface by eddy correlation methods. Wave generation measurements using wave-following pressure and wind sensors. Operation of stable floating platform. Participation in IFYGL, JONSWAP and AIDJEX.
(*h*) **Wind Stress on Arctic Sea Ice,** E. G. Banke, S. D. Smith, *J. Geophys. Res.* **78**, 33, pp. 7871-7883, *BIO Contribution 381*, Nov. 1973.
The Wind Blows, The Waves Come, F. W. Dobson, *Oceanus* **17**, pp. 29-35, Spring 1974.
Eddy Correlation Measurements of Evaporation and Sensible Heat Flux Over Arctic Sea Ice, M. R. Thorpe, E. G. Banke, S. D. Smith, *J. Geophys. Res.* **78**, 18, pp. 3573-3584, *BIO, Contribution 346*, June 1973.
Eddy Flux Measurements Over Lake Ontario, S. D. Smith, *Boundary-Layer Meteorol.* **6**, pp. 235-255 (Brocks Memorial Volume), Mar./Apr. 1974.

UNIVERSITY OF BRITISH COLUMBIA, Department of Mechanical Engineering, Vancouver, B. C. V6T 1W5, Canada. J. P. Duncan, Department Head.

405-06576-030-00

VORTEX-EXCITED OSCILLATION PHENOMENA FOR D-SECTION AND CIRCULAR CYLINDERS

(*c*) Dr. G. V. Parkinson.
(*d*) Experimental plus theoretical studies.
(*e*) To learn more of the kinematics and dynamics of the organized vortex systems in the wake of bluff, two-dimensional bodies. In particular, the interactions between the vortex systems and elastically mounted cylinders caused to oscillate by the vortices are of interest in the region of capture of the vortex frequency by the cylinder frequency.

405-06903-030-90

AEROELASTIC AND HYDROELASTIC GALLOPING OF BLUFF CYLINDERS

(*b*) NRC Canada.
(*c*) Dr. G. V. Parkinson.
(*d*) Experimental and theoretical studies.
(*e*) A quasi-steady theory is used to predict the galloping of an elastically mounted bluff cylinder; for a square cross-section in air flow, predictions and experimental results are in close agreement. In water flow the theory predicts "asynchronous quenching" of oscillations; experimental investigations of this phenomenon are underway in a low turbulence water tunnel for various cross-sections of bluff cylinders.

405-09502-000-90

A STUDY OF CIRCULAR COUETTE FLOW BY LASER DOPPLER MEASUREMENT TECHNIQUES

(*b*) NRC Canada.
(*c*) Dr. I. S. Gartshore.
(*d*) Experimental, M.A.Sc. thesis.
(*e*) Couette flow, one of the simplest of turbulent shear flows, is created in water between concentric cylinders with gap-to-radius ratio of about .05. Mean velocity profiles were measured for laminar and turbulent flow using the laser Doppler system, thereby eliminating direct probe interference.
(*f*) Completed.
(*g*) Experiments have been completed. Distortion due to end effects is noted in the laminar case but the turbulent mean velocity profiles are shown to conform well to a proposed "three-region" analytical model. Estimates of skin friction and Reynolds stress are made from the measured profiles.
(*h*) *M.A.Sc. Thesis.*

CANADA CENTRE FOR INLAND WATERS, Hydraulics Division, 867 Lakeshore Road, Burlington, Ontario, Canada, L7R 4A6. T. M. Dick, Division Chief.

406-07855-200-00

REAERATION IN OPEN-CHANNEL FLOW

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, theoretical; applied research.
(*e*) Investigate the mechanism of atmospheric reaeration in order to obtain more accurate predictions of the reaeration rate and means of improving the oxygen content through manipulation of the hydraulic variables.
(*f*) Completed.
(*g*) Experimental measurements of reaeration were conducted in a recirculating flume. A family of curves were obtained relating the dimensionless reaeration parameter to the Reynolds number and the friction factor. These results indicate that one cannot use a single equation for the reaeration coefficient to cover all ranges of flow.
(*h*) **An Experimental Investigation of Reaeration in Open-Channel Flow,** *Proc. 7th Conf. Intl. Assoc. Water Poll. Res.*, Paris, France, Sept. 1974.

406-07856-060-00

PRELIMINARY SURVEY OF FLOW REGIMES IN BURLINGTON CANAL

(*d*) Field investigation, applied research.
(*e*) Two flow regimes have been observed in Burlington Canal which connects a bay to Lake Ontario – gravity flow due to the variation of lake water level, and thermal wedge. The results will help to estimate the mass exchanged between the lake and bay.
(*f*) Completed.
(*g*) The study of the exchange flow between Hamilton Harbour and Lake Ontario revealed the necessity to consider short-term transitory water level fluctuations to estimate mass exchange. Field studies indicated the development of a thermal wedge in the summer. A two-layered system theory has been found adequate for the description of the observed phenomena.
(*h*) **Interfacial Shear Stress in Density Wedges,** T. M. Dick, J. Marsalek, *Proc. 1st Canad. Hydraul. Conf.* Univ. Alberta, Edmonton, May 1973.
Exchange Flow Between Lake Ontario and Hamilton Harbour, T. M. Dick, J. Marsalek, *Scientific Series No. 36, Inland Waters Directorate, Catalogue No. En 36-502/36*, Ottawa, Ontario, Canada.

406-09503-850-90

FISH PASSAGE-THROUGH CULVERTS

(*b*) Environmental Working Group, Mackenzie Highway Project, Canada Department of Public Works.
(*c*) P. Engel, Hydraulics Engineer.
(*d*) Design, operation, development.
(*e*) The project was aimed at providing a means for fish to pass through large highway culverts during spawning runs. Most stream crossings on the Mackenzie Highway will be made using large steep culverts and consequently velocities will be too high for fish migration. A model of a culvert was constructed to design and test devices which will provide regions of low currents. At the same time care was taken to keep hydraulic losses to a minimum.
(*f*) Completed.
(*g*) Three different designs of fish passage facilities were proposed, called Spoilers, Offset Baffles and Side Baffles. Each design has been recommended for specific range of flow depths and culvert slope. The effectiveness of all three designs is inversely proportional to culvert slope. The maximum recommended slope is five percent.
(*h*) **Fish Passage Facilities for Culverts on the Mackenzie Highway,** P. Engel, *Hydraulics Div. Report*, 70 pages, May 1974.

406-09504-350-90

WEIR MODEL STUDY

(*b*) Water Survey of Canada, Ontario Region, Department of the Environment.
(*c*) P. Engel, Hydraulics Engineer.
(*d*) Operation.
(*e*) Develop a rating curve for a composite weir in a small research basin. A model of the weir at a scale of 1:2 was constructed and model measurements over a range of flows exceeding the 50 year flood were made.
(*f*) Completed.
(*g*) A stage-discharge curve was developed to an accuracy within that attainable in the prototype. Prototype and model measurements showed good agreement. Observations are made regarding the sensitivity of the prototype weir and the errors which can be incurred with its design.
(*h*) **Stage-Discharge Curve for Perch Lake Weir,** P. Engel, *Hydraulics Div. Report*, 44 pages, Nov. 1974.

406-09505-220-90

HYDROGRAPHIC TECHNIQUE FOR BED-LOAD DISCHARGE

(*b*) Cooperative with Sediment Surveys Section, Water Survey of Canada, Department of Environment.
(*c*) Dr. C. K. Jonys.
(*d*) Experimental laboratory.
(*e*) To establish field measurement criteria for the determination of bed-load transport from spatial and temporal survey of bed form movement in large sand bed rivers.

406-09506-700-90

MEASUREMENT OF BED-LOAD WITH HYDROPHONE

(*b*) Cooperative with Sediment Surveys Section, Water Survey of Canada, Department of Environment.
(*c*) Dr. C. K. Jonys.
(*d*) Experimental laboratory; theoretical; field; applied developmental research.
(*e*) Feasibility study to detect and measure bed-load transport by observation and analysis of noise generated by collisions of gravel particles in rivers.

406-09507-300-00

DISPERSION IN MEANDERING CHANNELS

(*c*) Dr. B. G. Krishnappan and Dr. Y. L. Lau.
(*d*) Experimental, theoretical; applied research.
(*e*) Project is aimed at measuring the transverse dispersion coefficient in laboratory meandering channels for various geometrical configurations. Results of this project would reveal the effects of the secondary currents caused by the meander on the dispersion process.
(*g*) Measurements made so far indicate that the transverse dispersion coefficient increases with the amplitude of meander. The depth variation across the channel cross-section plays an important role in the convective transport and consequently the overall dispersion.
(*h*) **Transverse Dispersion in Meandering Channels,** B. G. Krishnappan, Y. L. Lau, *Proc. Intl. Conf. Transport of Persistent Chemicals in Aquatic Ecosystems*, Univ. Ottawa, May 1974.

406-09508-220-00

DISPERSION OF GRANULAR MATERIAL DUMPED IN DEEP WATER

(*c*) Dr. B. G. Krishnappan.
(*d*) Experimental; applied research.
(*e*) Project is aimed at studying the behavior of the granular material when dumped as a slug in deep water. This knowledge is essential for the study of the dispersal of the dredged material when released in deep water from a barge with bottom opening.
(*f*) Completed.
(*g*) The motion of dredged material dumped near the surface of deep water is formulated using the principle of superposition. The dredged material is considered to consist of various fractions of uniform size particles and each fraction affects the total behavior of the dredged material proportionally to its negative buoyancy. The behavior of uniform size particles has been formulated using the theory of dimensions and laboratory experiments. The results show that the motion of particles can be treated in two distinct phases, namely, the initial "entrainment" phase and the "settling" phase. During the entrainment phase, the size of the "cloud" grows due to the incorporation of external fluid while the vertical downward velocity diminishes. During the settling phase when the vertical downward velocity is the same as the fall velocity of the individual solid particles constituting the cloud, the increase in the cloud size is solely due to ambient turbulence.
The method developed permits the evaluation of the height and horizontal size of the "mound" formed by the deposition of the dredged material at the bottom of the deep water. It also indicates how the above characteristics of the mound depend on the volume of the dump, the size distribution of the dredged material and the water depth, thereby, providing the guidance for the selection of optimum dump size and the location for the disposal of the dredged material.
(*h*) **Dispersion of Granular Material Dumped in Deep Water,** B. G. Krishnappan, *Hydraulics Div. Report*, Nov. 1974.

406-09509-200-00

TRANSVERSE DIFFUSION IN OPEN-CHANNEL FLOW

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, basic research.
(*e*) Investigate the dependence of the diffusion coefficient on the different flow variables.
(*g*) Experiments are in progress.

406-09510-870-00

CRITERIA FOR OIL-SLICK CONTAINMENT IN FLOWING WATER USING BOOMS

(*c*) Y. L. Lau.
(*d*) Experimental, applied research.
(*e*) Obtain criteria for oil spill containment and to produce realistic estimates of volume of oil containable under given flow conditions, conditions under which no containment is possible and feasibility of diverting oil slicks using booms under such conditions.
(*g*) A review was completed. Experiments are continuing.
(*h*) **A Review of the Dynamics of Contained Oil Slicks,** Y. L. Lau, S. A. Kirchhefer, Hydraulics Div. unpublished report.

406-09511-810-00

MODELING OF URBAN RUNOFF

(c) J. Marsalek.
(d) Theoretical and field investigation.
(e) Selected urban runoff models are evaluated by comparing the computer simulations with field observations.
(h) **Modern Concepts in Urban Drainage Design,** J. Marsalek, T. M. Dick, P. E. Wisner, *Hydraulics Div. Report*, May 1974.
Comparative Evaluation of Three Urban Runoff Models, J. Marsalek, T. M. Dick, P. E. Wisner, W. G. Clarke, *Water Resour. Bull.* (*AWRA*), in press.

406-09512-870-00

ENERGY LOSSES AT SEWER PIPE JUNCTIONS

(c) J. Marsalek.
(d) Experimental; applied research.
(e) Energy losses at sewer pipe junctions are determined experimentally for various geometrical configurations under free flow conditions.

406-09513-420-00

WAVE ENERGY AT POINT PELEE, LAKE ERIE

(c) M. G. Skafel and T. M. Dick.
(d) Field investigation, theoretical.
(e) Waves were recorded during 1974 off the east and west sides of Point Pelee to establish the wave climate on each side and to provide data for other field projects investigating sediment movement along the coast. Using wind climate information and hindcasting techniques the frequency of occurrence of waves around the point will be determined and compared to field measurements. Numerical methods will be used to estimate the wave energy at the breaker zone and estimates of littoral drift will be made to define regions of erosion and accretion. The results will be correlated with past long-term movement of the point with the aim of predicting likely future movement.

406-09514-870-00

OIL SPILL CONTAINMENT AND CONTROL ON ST. CLAIR AND DETROIT RIVERS IN WINTER

(c) Dr. G. Tsang.
(d) Theoretical, applied.
(e) Study the ice conditions on the St. Clair and Detroit Rivers, the probability of winter oil spill, and the containment of control of spilled oil on the rivers under winter conditions.
(f) Completed.
(g) Winter oil spill is quite probable on the St. Clair and Detroit Rivers. Different ice conditions may be encountered at different sections. The ice and oil can be contained and then separated by flow boom(s) properly designed and deployed.
(h) **A Study on the Ice Conditions and the Containment and Removal of Spilled Oil on St. Clair and Detroit Rivers,** G. Tsang. unpublished report for Operation Preparedness, *Oil Spill on St. Clair and Detroit Rivers* (Canada Centre for Inland Waters publication).

406-09515-300-00

FRICTION COEFFICIENT OF ICE COVERED RIVERS

(c) Dr. G. Tsang.
(d) Field, basic, applied.
(e) Study the friction coefficient of ice covered rivers as compared with open water conditions.
(f) Field program completed.
(g) Being compiled.

406-09516-410-00

ICE PILING ON LAKE SHORES

(c) Dr. G. Tsang.
(d) Field, basic, applied.
(e) Study the cause and phenomena of ice piling on shores.
(f) Field program completed.
(g) Report being prepared. It was found that the primary cause of ice piling is the change of wind direction from off-shore to on-shore. An open water lead is necessary for the ice floe to build up momentum.
(h) **Ice Piling on Lake Shores, with Special Reference to the Occurrences on Lake Simcoe in the Spring of 1973,** G. Tsang, *Proc. IAHR Symp. River and Ice*, Budapest, Jan. 1974. Revised version also published as *Scientific Series Publication No. 35*, Inland Waters Directorate, Dept. of the Environment, 1974. (Available through Information Canada, Ottawa, Quote Cat. No. En 36-503/35).

406-09517-390-00

FORMATION OF FRAZIL ICE IN WATER WITH SURFACE WAVES

(c) Dr. G. Tsang.
(d) Theoretical, basic.
(e) Study the heat flux and the formation of ice in water when subject to sinusoidal surface waves of various amplitude and frequency.
(h) **Conceptual Design of a Multi-Purpose Instrument for Winter Stream Metering,** G. Tsang, *Proc. Interdisciplinary Symp. Advanced Concepts and Techniques in the Study of Snow and Ice Resources*, National Acad. Sci., 1974.
Preliminary Investigation and Experimental Set-Up for the Study of Frazil Formations in Water with Surface Waves, G. Tsang, *Proc. Seminar Ice Thermal Regimes*, Laval University, Oct. 1974. In press. Paper may be obtained through Division of Building Research, National Research Council, Ottawa.

DALHOUSIE UNIVERSITY, Institute of Oceanography, Halifax, Nova Scotia, Canada B3H 3J5. Dr. Lloyd M. Dickie, Director.

407-09518-420-00

SURF ZONE AND NEARSHORE HYDRODYNAMICS

(c) A. J. Bowen and D. A. Huntley.
(d) Theoretical and field experimental; basic research.
(e) Develop theories of nearshore wave/motion and steady currents, and test theories by field experiments. Investigation of surf beat, edge waves and turbulent stresses on bottom sediment.
(g) See papers.
(h) **Comparison of the Hydrodynamics of Steep and Shallow Beaches,** D. A. Huntley A. J. Bowen, *Proc. Symp. Nearshore Sediment Dynamics and Sedimentation*, Southampton, Oct. 1973 (Ed. J. R. Hails and A. Carr), Loundon: Wiley.
Direct Measurement of Nearshore and Surf-Zone Velocities, *Proc. 14th Conf. Coastal Engrg.*, Copenhagen, June 1974, New York: ASCE.

ENVIRONMENT CANADA, INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY; OCEAN AND AQUATIC AFFAIRS, PACIFIC, 1230 Government Street, Victoria, British Columbia, Canada V8M 1Y4. R. W. Stewart, Director-General.

408-09519-410-00

MATHEMATICAL MODEL OF BURRARD INLET, B. C.

(c) Mr. A. B. Ages.
(d) Theoretical; applied research.
(e) A two-dimensional numerical model, using finite difference methods for calculating tidal propagation in Burrard Inlet, including Vancouver Harbour, Indian Arm and Port Moody.

408-09520-300-00

MATHEMATICAL MODEL OF FRASER DELTA, B. C.

(*c*) Mr. A. B. Ages and Miss A. Woollard.
(*d*) Theoretical; applied research.
(*e*) A one-dimensional numerical model, using finite difference methods for calculating tidal heights in the Fraser Delta, to improve tidal predictions for shipping and pollution problems. The accuracy and limitations of a numerical model to predict tides in an estuary are examined by comparing the results with several years of observed values, and by introducing perturbations in the boundary conditions.
(*g*) Final report in progress.

408-09521-060-90

THE BEHAVIOR OF THE SALINE WEDGE IN THE FRASER DELTA

(*b*) University of B. C. and National Research Council of Canada.
(*c*) Dr. G. C. Hughes (U.B.C.) and Mr. A. B. Ages.
(*d*) Field investigation; applied research.
(*e*) A study of the movement of the salinity wedge as a result of the interaction of the Fraser River discharge and the tides in the Strait of Georgia was continued by observing salinities and temperatures from ship board.
(*g*) Final report in progress.

408-09522-390-00

SIMULATION OF AN UNDERSEA OIL/GAS WELL BLOWOUT

(*c*) Dr. D. R. Topham.
(*d*) Experimental and theoretical; basic research.
(*e*) Investigate the flow fields within and around the bubble plume arising from a single point source of air released on the sea bed. The experiment was designed to simulate the effects of an undersea oil well releasing up to 1300 cubic ft/min of free gas.
(*f*) Final report in progress.
(*g*) Experiments were carried out at depths of 200 ft and 50 ft, the former at flow rates up to 900 cubic ft/min of free air, the latter up to 2000 cubic ft/min of free air. Vertical velocities up to 2.5 ft/sec were measured within conical plumes of 6° half angle. A flow division in the horizontal surface currents formed a containing ring roughly 130 ft in diameter for the 200 ft plume.

LASALLE HYDRAULIC LABORATORY LTD., 0250 St. Patrick Street, LaSalle, Quebec, Canada H8R 1R8. R. Hausser, Vice President and General Manager.

409-07860-340-73

INDIAN POINT NUCLEAR POWER STATION - UNIT 2

(*b*) Consolidated Edison Company of New York.
(*d*) Experimental, design.
(*e*) Anexisting model of one screenwell used to develop optimum layout for perforated air pipes to create curtain of bubbles in front of intake screens as a means of stopping fish.
(*f*) Completed.

409-07861-870-36

FUNDAMENTAL RESEARCH ON SWIRL CONCENTRATOR

(*b*) American Public Works Association as management agent for a research grant from the U. S. Environmental Protection Agency.
(*d*) Basic research.
(*e*) The swirl concentrator principle was developed earlier for use as a stormwater regulator. Present work has been directed toward its use as a grit chamber, primary settler and for erosion runoff treatment.
(*g*) Laboratory studies are completed. Prototype pilot units of grit chamber and primary settler being monitored to check scale-up procedures from model.

409-07862-340-96

MICA CREEK HYDROELECTRIC PROJECT

(*b*) British Columbia Hydro and Power Authority.
(*d*) Experimental; design.
(*e*) 1/84 scale model study to define detailed structural changes of underground manifolds and tailrace tunnels. Load acceptance and rejection surges were major parameters in selecting tunnel level settings, and operating procedures. Limiting surge levels were found and corresponding acceptable operations specified as a function of the tailwater conditions.
(*f*) Completed.

409-09523-370-96

HIGHWAY BRIDGE OPENING (CHAUDIERE RIVER)

(*b*) Ministry of Transport, Quebec.
(*d*) Model investigation.
(*e*) Model constructed to a horizontal scale of 1:150 and to a vertical scale of 1:60 (reproducing 11,250 feet of the river). Hydraulic investigation including clear water tests, aimed at determining backwater effect and scour conditions, and systematic ice tests on ice cover formation and ice jamming processes.
(*f*) Completed.

409-09524-370-96

HIGHWAY BRIDGE OPENING (DES PRAIRIES RIVER)

(*b*) Ministry of Transport, Quebec.
(*d*) Model investigation.
(*e*) Model constructed to a horizontal scale of 1:300 and to a vertical scale of 1:100 (reproducting about 5 miles of the river). Clear water tests at various flood flows. Ice tests (ice cover formation and ice jamming processes). Determination ofbridge effect.
(*f*) Completed.

409-09525-030-90

EXPERIMENTAL STUDY ON FLOW INDUCED VIBRATION AND FRETTING WEAR OF HEAT EXCHANGER TUBES

(*b*) Atomic Energy of Canada Limited.
(*d*) Experimental, development.
(*e*) Experimental investigation to determine the vibration and fretting wear behavior of titanium alloy tubes relative to stainless steel tubes (acceleration measurements, wear observations).
(*f*) Completed.

409-09526-860-97

WATER FILTRATION PLANT CHARLES J. DES BAILLETS

(*b*) City of Montreal; Lalonde, Valois, Lamarre, Valois and Associates, Counsulting Engineers.
(*d*) Model investigation.
(*e*) Hydraulic model investigations on four 1:24 scale models to aid in the design of the chlorination basin, the gate chambers and the pumping basins (high pressure and low pressure).
(*f*) Completed.

409-09527-370-97

HYDRAULIC INVESTIGATION ON CATCH BASINS

(*b*) City of Montreal.
(*d*) Model investigation.
(*e*) Determination of the capacity of various types of gutter and curb inlets on a model built to a scale of 1:2.
(*f*) Completed.

409-09528-870-70

RAYONIER QUEBEC OUTFALL SEWER, PORT CARTIER

(*b*) Rayonier Quebec Incorporated.
(*d*) Model investigation.
(*e*) Wave flume tests at scale 1:60 to investigate the stability of the diffuser section for the expected waves.
(*f*) Completed.

409-09529-340-75

LG2 WATER INTAKE

(*b*) Rousseau, Sauvé, Warren, Inc., Consulting Engineers; James Bay Energy Corporation.
(*e*) A 1/100 scale model including the penstock entrances and the intake canal was built to optimize the rock excavation in front of the intakes and to aid in the design of the structure. The tests included vortex observations, chronophotographic surface velocity determination, head loss measurements, tests on ice boom effectiveness.

409-09530-340-73

INDIAN POINT NUCLEAR POWER STATION – COMMON INTAKE

(*b*) Consolidated Edison Company of New York, Incorporated.
(*d*) Experimental; design.
(*e*) The power complex includes three units, each having its own individual cooling water intake located near the river shore, in areas subjected to only slow river tidal velocities. The project was to concentrate the water capture from the river at one location in order to reduce the approach velocity such that fish would no longer be drawn onto the travelling screens. The structure was to be located further out into the river where higher velocity tidal flows were to be intercepted. Investigation on a 1/30 scale model was made of the flow distribution at the common intake under various hydraulic conditions, and to the flow along the canal leading to the individual pumphouse intakes.
(*f*) Completed.

409-09531-350-87

TEMENGOR HYDRO-ELECTRIC PROJECT – CHUTE SPILLWAY

(*b*) National Electricity Board of the States of Malaya; The Shawinigan Engineering Company Limited, Montreal.
(*d*) Experimental; design.
(*e*) A chute spillway was designed to carry a peak outflow of 100,000 cfs through a control structure of the free overflow type without gates. Investigation was made on a 1/100 scale model of the control structure and chute and on the scouring effect on the riverbed from the jet coming from the flip bucket.
(*f*) Completed.

409-09532-340-96

GENTILLY NUCLEAR POWER STATION UNIT NO. 2 – THERMAL DISCHARGE

(*b*) Hydro Quebec.
(*d*) Experimental; design.
(*e*) A second unit of 600 MW will be built close to the existing 250 MW unit. A 1/600 by 1/150 scale model reproducing nine miles of the St. Lawrence River was built to study the hydraulic conditions and the diffusion of the heated discharge. Investigation was made on the influence of tide and wind conditions over risks of recirculation through the intake canals. Investigation was also made on the capability of the site to accept other units from the standpoint of thermal impact.
(*f*) Completed.

409-09533-870-75

RETURN LINE FROM AN AERATED LAGOON

(*b*) T. W. Beak Consultants Limited, Montreal.
(*d*) Theoretical; design.
(*e*) Hydraulic analysis and recommendation were made for the return line from an aerated lagoon of a pulp and paper second treatment plant. Water will be pumped into that lagoon 170 feet higher than the river water level for aeration purposes and will return by gravity to the river located some 12,000 feet away. Two alternatives were studied for the return line: pressure flow and free surface flow.
(*f*) Completed.

409-09534-340-73

LG-2 JAMES BAY PROJECT – DIVERSION TUNNELS

(*b*) James Bay Energy Corporation; Asselin, Benoit, Boucher, Ducharme, Lapointe, Inc., Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) Study on a 1/100 scale model of the pre-diversion and final closure of the river. Investigation on the entrance and outlet works of the two diversion tunnels to achieve proper diversion conditions. Simulation of the passage of ice through the tunnels and of the possible erosion of the riverbed under given flow conditions.
(*f*) Completed.

409-09535-330-96

BEAUHARNOIS CANAL – ICE CONTROL AT THE ENTRANCE

(*b*) Hydro Quebec; The St. Lawrence Seaway Authority.
(*d*) Experimental; design.
(*e*) The Beauharnois Canal is used for navigation and electricity production purposes. A 1/600 by 1/150 scale model reproducing a portion of Lake St. Francis at the entrance to the canal and a 2.5 mile reach of the canal was used to define the characteristics of an ice boom structure. This structure would be used to control ice movement at the closure and opening of the navigation season in order to avoid untimely ice cover formation in the canal.
(*f*) Completed.

409-09536-870-97

MONTREAL SEWERAGE SYSTEM – INTERCEPTION WORKS

(*b*) Montreal Urban Community.
(*d*) Experimental; design.
(*e*) Model study to achieve satisfactory operation of the diversion and regulating chambers and of the vertical shaft designed to divert sewage flow from the main sewers into the intercepting sewer. Study was carried out on a 1/12 scale model reproducing each one of the three structures preliminary design to intercept a nominal flow. Extrapolation of results through similitude laws allowed proper dimensioning of other structures designed to intercept various flow quantity.
(*f*) Completed.

409-09537-340-73

POWER DEVELOPMENT OF LA GRANDE RIVER, JAMES BAY PROJECT

(*b*) James Bay Energy Corporation.
(*d*) Theoretical.
(*e*) Study of the general effects of power development of La Grande River on the flow conditions. Investigation was made to evaluate the impact of flow increase over ice conditions and riverbed transportation following different power development schemes.

409-09538-350-96

LONG SPRUCE GENERATING STATION

(*b*) Manitoba Hydro, through Crippen Acres Engineering.
(*d*) Experimental; design.
(*e*) Hydraulic model study of downpull forces on the diversion sluice closure gates. Model scale: 1/50.
(*f*) Completed.

(*g*) Modification of the gate bottom design helped to reduce considerably the total maximum downpull force on the gate.
(*h*) Final report submitted to Manitoba Hydro and Crippen Acres Engineering, May 1974.

409-09539-340-75

THREE MILE ISLAND STATION – UNIT 2

(*b*) Burns and Roe Inc., Consulting Engineers, Oradell, N. J.
(*d*) Experimental; design.
(*e*) Study of pump chambers and balancing connections on a 1:10.5 hydraulic scale model.
(*f*) Completed.
(*g*) With the initially proposed arrangement the discharge conditions were unsatisfactory. The design developed on the model without changing the basic pump chamber dimensions provided desired discharge and flow conditions.
(*h*) Final report submitted to Burns and Roe, Inc., June 1974.

409-09540-300-99

POST-DIVERSION ICE REGIME STUDY OF THE LOWER CHURCHILL RIVER

(*b*) Lake Winnipeg, Churchill and Nelson Rivers Study Board, Winnipeg, Manitoba.
(*d*) Theoretical computations.
(*e*) Comparative study of the ice cover formation and accumulation under three given discharge conditions.
(*f*) Completed.
(*g*) The impacts of drastic flow reduction on the winter flow conditions of the river were assessed and recommendations made.
(*h*) Final report submitted to the study board, May 1974.

409-09541-340-75

HANFORD NUCLEAR PROJECT NO. 2

(*b*) Burns and Roe, Inc., Consulting Engineers, Oradell, N. J.
(*d*) Theoretical, experimental; design.
(*e*) Theoretical computations, and air and hydraulic model studies (model scales 1:3.3 and 1:25, respectively) were carried out to develop an acceptable design of all elements of the perforated pipe inlet and the protective dolphin of the makeup water pump station of the Hanford Nuclear Project No. 2.
(*f*) Completed.
(*g*) Use of an internal sleeve helped to obtain a very uniform flow distribution offering maximum protection to small fish under all operating conditions. Use of a large scale (1:3.3) air model enabled precise velocity measurements in the vicinity of external screen and internal sleeve perforations.
(*h*) Final report submitted to Burns and Roe, Inc., February 1974.

409-09542-410-75

FALSE CREEK DEVELOPMENT

(*b*) Golder Brawner and Associates, Consulting Engineers, Vancouver.
(*d*) Theoretical; design.
(*e*) Preliminary study of the effect of tidal sediment transport and water exchange on the proposed shore development projects in False Creek.
(*f*) Completed.
(*g*) Long term sediment transport and water exchange patterns were established and recommendations made.
(*h*) Final report submitted to Golder Brawner and Associates, February 1973.

409-09543-340-96

LONG SPRUCE GENERATING STATION

(*b*) Manitoba Hydro, through Crippen Acres Engineering.
(*d*) Experimental; design.
(*e*) Hydraulic studies on 1:50 partial model and 1:100 comprehensive model of the following aspects: Stage I cofferdam construction, and summer and winter diversion; Stage II cofferdam construction and diversion; best construction bridge location; power intake and tailrace; spillway and scour.
(*f*) Completed.
(*g*) Model studies helped to improve conception of cofferdam construction and diversion schemes, increase the efficiencies of various structures and their safety, introduced some savings in the overall construction costs.
(*h*) Final reports submitted to Manitoba Hydro and Crippen Acres Engineering, May, June, July 1974.

409-09544-330-90

LAKE ST. PIERRE CHANNEL SILTATION STUDY

(*b*) Ministry of Transport, Waterways Development Canada.
(*d*) Theoretical; field investigation and bibliographic research.
(*e*) Determine the causes of the channel evolution observed over a period of two years in the excavated section of the navigation channel in Lake St. Pierre on St. Lawrence River, and if possible propose remedial measures.
(*f*) Completed.
(*g*) Analysis of field results permitted the explanation of the various possible reasons of the channel evolution observed. Recommendations were made for further field investigations and alternative long-term solutions were proposed.
(*h*) Final report submitted to the Ministry of Transport, Waterways Development, September 1974.

409-09545-300-96

BURNTWOOD RIVER BETWEEN JACKPINE FALLS AND THREEPOINT LAKE

(*b*) Manitoba Hydro.
(*d*) Theoretical computations.
(*e*) Winter backwater and ice cover studies following Churchill River diversion.
(*f*) Completed.
(*g*) Maximum rise in winter water levels along the Burntwood River, due to important increase in the river discharge was computed and recommendations for further studies were made.
(*h*) Report submitted to Manitoba Hydro, December 1974.

409-09546-340-75

SENOKO POWER STATION THERMAL MODEL STUDY

(*b*) Montreal Engineering Company Limited.
(*d*) Experimental; design.
(*e*) 1:600 horizontal and 1:150 vertical scale thermal model study of dispersion characteristics of the discharge plume, the change in the average cooling water inlet temperature above ambient temperature and determination of the water surface contour of 2 °C temperature rise above ambient of the discharge heat plume.

409-09547-340-96

SITE I POWER INTAKE STUDIES

(*b*) British Columbia Hydro and Power Authority.
(*d*) Experimental; design.
(*e*) Hydraulic studies on a 1:48 partial model of the following aspects: intake head loss for different transition shapes between the gate section and the penstock; gate downpull and risks of vibration; vortex formation at the intake.

409-09548-870-90

OIL SPILLS

(*b*) Ministry of Transport – Canada.
(*d*) Experimental.
(*e*) Use of deflectors for diversion of a spill toward the North bank of the St. Lawrence River where the velocities are low enough for use of conventional means for recovery in case of oil spill along the Montreal Refinery. Determination of the phenomenon and location of deflector stacks for best efficiency.
(*f*) Interim reports.
(*g*) Possibility of greatly improving the recovery percentage in case of spill.

409-09549-330-90

NAVIGATION – TRAVERSE SPIT

(*b*) Ministry of Transport, Canada.
(*d*) Experimental.
(*e*) Study of the problems involving large vessels, as supertankers, during passage, meeting or overtaking in restricted waters of the St. Lawrence navigation channel. Specific case of traverse spit (at the top of Ile d'Orléans) under study, model and ships scale 1/100, radio and T. V. monitored ships.
(*f*) First interim report early in 1975.

409-09550-470-90

PORT OF QUEBEC

(*b*) Ministry of Transport, Canada.
(*d*) Model investigation.
(*e*) In conjunction with Consulting Engineer, 1:600 x 1:150 scale tide model for study of new development planned for the Port of Quebec.
(*f*) Completed.

409-09551-340-96

KOOTENAY CANAL DEVELOPMENT

(*b*) British Columbia Hydro and Power Authority.
(*d*) Experimental; design.
(*e*) 1/69 scale hydraulic model of supply canal, forebay and intake structure. Restricted available space in mountainous terrain resulted in original design causing serious vortex formation at intake. Development tests defined new canal alignment and intake structure to eliminate vortices.
(*f*) Completed.

409-09552-870-82

FUNDAMENTAL RESEARCH ON HELICAL CONCENTRATOR

(*b*) American Public Works Association as management agent for a research grant from the U. S. Environmental Protection Agency.
(*d*) Basic research.
(*e*) The principle being developed in this work was to use the secondary spiral flow in a bend to aid in settling and concentrating pollutants from stormwater discharges in sewers. Sensitive parameters were identified and design procedures laid out for practical use on the basis of removal efficiency for different sized particles.
(*f*) Completed.

409-09553-870-75

HYDROSPACE-CHALLENGER SEWAGE SAMPLER TESTS

(*b*) Hydrospace-Challenger Inc., Rockville, Md., as prime contractor on an instrument development grant from the U. S. Environmental Protection Agency.
(*d*) A one-foot wide channel, in which water and solids discharges could be accurately measured was used. Sewage sampling instruments were put in the channel and their indications compared with the known concentrations.
(*f*) Laboratory work completed as part of H.C.I. report to E.P.A. now in preparation.

409-09554-350-70

JACOPIE SPILLWAY STRUCTURE – CHURCHILL FALLS DEVELOPMENT

(*b*) Churchill Falls (Labrador) Corporation Limited.
(*d*) Experimental, calibration.
(*e*) 1/72 scale model of existing structure. Precise tests done at specified gate openings to define in detail the discharge calibration of the structure.
(*f*) Completed.

409-09555-340-73

INDIAN POINT NUCLEAR POWER STATION – UNIT 2

(*b*) Consolidated Edison Company of New York.
(*d*) Analytical, design.
(*e*) Mathematical model of cooling tower recirculating pipe system. Transient surges were computed for normal and accidental operations. Limiting valve times and suggested operation procedures defined.
(*f*) Completed.

409-09556-340-75

HANFORD UNIT 2 – MAKE-UP WATER PUMPWELL

(*b*) Burns and Roe, Inc., consultants to the Washington Public Power Supply System.
(*d*) 1/9 scale model of pumpwell. Studies to develop internal configuration that will give acceptable flow entry to the pump bellmouths.

409-09557-340-96

JENPEG GENERATING STATION

(*b*) Manitoba Hydro.
(*d*) 1/36 scale model study of powerhouse intakes to study operating conditions, downpulls, uplift and horizontal forces on stoplog elements being placed to shut off turbine runaway discharge.
(*e*) Model completed, studies under way.

409-09558-390-70

SAN JUAN PUMPING STATION, PUERTO RICO

(*b*) Babcock-Wilcox, pump manufacturers, Galt, Ontario.
(*d*) 1/12 scale model study of supply tunnel and pumpwells to determine sources of pump vibrations.
(*f*) Model completed, testing under way.

McGILL UNIVERSITY, Marine Sciences Centre, P. O. Box 6070, Station "A," Montreal, Quebec, Canada H3C 3G1. Dr. Max Dunbar, Chairman.

411-09563-400-90

VARIABILITY OF SUSPENDED MATTER IN THE ST. LAWRENCE ESTUARY

(*b*) National Research Council of Canada; Department of Education, Province of Quebec.
(*c*) Bruno d'Anglejan, Assoc. Professor.
(*d*) Field investigation; basic research; graduate student theses.
(*e*) A study of the variability of suspended matter concentration throughout the St. Lawrence estuary. Emphasis has been placed on trying to relate the changes of tidal currents, stratification and bottom topography to the observed changes. Recent work using simultaneously observed current and suspended matter profiles has been employed to investigate short period fluctuations in concentration.
(*h*) **Distribution, Transport, and Composition of Suspended Matter in the St. Lawrence Estuary,** B. d'Anglejan, E. Smith, *Can. J. Earth Sci.* **10**, 9, pp. 1380-1396, 1973.
First Subbottom Acoustic Reflector and Thickness of Recent Sediments in the Upper Estuary of the St. Lawrence River, B. d'Anglejan, M. Brisebois, *Can. J. Earth Sci.* **11**, 2, pp. 232-245, 1974.
Tidal Induced Fluctuations of Suspended Matter in the St. Lawrence Estuary, R. G. Ingram, B. d'Anglejan, *AGU Conf. Transport Mechanisms in the Nearshore*, Sept. 1974.

411-09564-400-90

CIRCULATION AND MIXING IN THE ST. LAWRENCE ESTUARY

(*b*) National Research Council of Canada; Department of Education, Quebec.
(*c*) R. Grant Ingram, Asst. Professor.
(*d*) Basic research employing a large amount of field investigation. Graduate theses on some of the material have been completed.

(*e*) The project goal initially centered on a physical explanation for the high primary productivity of the estuary. To obtain an understanding of the relevant dynamical processes, long-term current meter moorings, and STD and current meter profiling over one or two tidal cycles at numerous stations were employed. Numerous side projects evolved in the course of this study.

(*h*) **Winter Surface Currents around Cape Breton Island,** R. G. Ingram, *J. Fish. Res. Bd. Canada* **30,** 1, 1973.
Current Meter Profiling Results from the St. Lawrence Estuary, R. G. Ingram, *Proc. Phys. Oceanog. Workshop,* Rimouski, Dec. 1973.
Influence of Tidal Induced Vertical Mixing on Primary Production in the St. Lawrence Estuary, R. G. Ingram, *Proc. Roy. Soc. Liege,* 1975 (in press). *Conf. in Hydrodynamics,* May 1974.
Tidal Induced Fluctuations of Suspended Matter in the St. Lawrence Estuary, R. G. Ingram, B. d'Anglejan, *AGU Conf. Transport Mechanisms in the Nearshore,* Sept. 1974.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND, Faculty of Engineering and Applied Science, St. John's, Newfoundland, Canada A1C 5S7. Dr. R. T. Dempster, Dean.

412-09565-050-90

STUDIES OF BUOYANT JET PHENOMENA

(*b*) National Research Council of Canada.
(*c*) J. J. Sharp, Associate professor.
(*d*) Experimental and theoretical, basic research.
(*e*) The effect of a boundary close to the jet is being studied with a view to predicting mixing characteristics and developing a pre-dilution device.
(*g*) The boundary has been shown to increase dilution up to 150 percent of that experienced by free jets.
(*h*) **Bottom Effects on Dilution of Buoyant Jets,** J. J. Sharp, C. Wang, *Water Poll. Res. in Canada 1973,* Univ. of Toronto Press.

412-09566-210-90

WATERHAMMER WITH ABSTRACTIONS

(*b*) National Research Council of Canada.
(*c*) J. J. Sharp, Associate Professor.
(*d*) Theoretical, basic.
(*e*) The effects of abstracting part of the main flow are being considered and approximate methods of analysis are under development.

412-09567-390-90

ICE FORCES ON PIERS AND PILES

(*b*) National Research Council of Canada.
(*c*) C. R. Neill, Associate Professor.
(*d*) Analytical, applied research.
(*e*) Theoretical, field and model studies (as reported in the literature), of forces developed by ice moving against piers and piles, are being reviewed in order to evaluate current design practice and design codes or guidelines. Proposals will be developed for improved design guidelines and research priorities.
(*g*) Current practice in determining design ice forces on piers and piles lags behind recent research findings. Research results demonstrate the significance of various factors which are not properly accounted for in the usual design procedures.
(*h*) **Selected Aspects of Ice Forces on Piers and Piles,** C. R. Neill. Preprint for *Atlantic Region Hydrotech. Conf., Can. Soc. Civil Engrg.,* Nov. 1974 (typescript available from author).

412-09568-370-90

BRIDGE HYDRAULICS

(*b*) National Research Council of Canada and Roads and Transportation Association of Canada.
(*c*) C. R. Neill, Associate Professor.
(*d*) Field, applied research.
(*e*) Data on bridge waterway dimensions and river bed scour, collected by Canadian highway departments, are being examined with a view to evaluating published design recommendations.
(*h*) **Guide to Bridge Hydraulics,** C. R. Neill (Editor), Roads and Transportation Assoc. of Canada with Univ. of Toronto Press, 1973.

NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering, Hydraulics Section, Montreal Road, Ottawa, K1A 0R6, Canada. J. Ploeg, Section Head.

413-06602-400-90

TIDAL HYDRAULIC MODEL OF THE ST. LAWRENCE RIVER AND ESTUARY

(*b*) Ministry of Transport.
(*c*) Mr. J. Ploeg, Dr. B. D. Pratte.
(*d*) Experimental, applied research.
(*e*) A hydraulic model of the tidal reach of the river has been constructed and calibrated for the study of navigation improvements.
(*h*) **Computer Control and Data Acquisition of a Tidal Model,** E. R. Funke, *MH-110,* Dec. 1972.

413-06603-400-90

MATHEMATICAL MODEL OF THE ST. LAWRENCE RIVER AND ESTUARY

(*b*) Ministry of Transport.
(*c*) N. Crookshank.
(*d*) Theoretical; applied research.
(*e*) A combined one- and two-dimensional numerical model, using finite difference methods of calculating tidal propagation along the St. Lawrence River.
(*h*) **Numerical Model Studies of the St. Lawrence River,** D. Prandle, N. Crookshank, July 1972.

413-07098-420-00

WAVE DIRECTION STUDY

(*c*) Mr. J. Ploeg.
(*d*) Field study; theoretical; basic research.
(*e*) Using a triangular array of wave sensors in deep water in Lake Ontario, Ontario, measurements are being made to determine the direction of propagation of wind generated waves and to calculate the actual wave lengths, corresponding to peaks in frequency spectrum.

413-08133-420-90

FORCES ON OFF-SHORE STRUCTURES

(*b*) Public Works – Canada.
(*c*) Dr. G. Mogridge, W. Jamieson.
(*d*) Experimental, theoretical; applied research.
(*e*) Using a scale model of a deep water off-shore mooring point, wave forces sensed by strain gauges are recorded on-line with an EAI-640 computer. Regular and random waves are used.
(*h*) **Instrumentation to Measure Wave Forces on a Model Pile,** B. D. Pratte, *HY-80,* Apr. 1972.

413-09559-470-90

CHURCHILL HARBOR MODEL STUDY

(*b*) National Harbours Board.
(*c*) Dr. B. D. Pratte.
(*d*) Experimental, applied research.
(*e*) A scale model study of the tidal portion of the Churchill River, Manitoba, to establish the effects of a newly proposed wharf on the flow pattern. Also the effects of diversion of upland flow of the Churchill River on the salinity intrusion will be investigated.

413-09560-470-90

PORT-AUX-BASQUES MODEL STUDY

(*b*) Public Works - Canada.
(*c*) J. Ploeg.
(*d*) Experimental, applied research.
(*e*) A hydraulic model of Port-Aux-Basques Newfoundland harbor is being used to investigate proposals to expand the extensive ferry terminals.

413-09561-470-90

GRAND BAY MODEL STUDY

(*b*) Ministry of Transport.
(*c*) J. Ploeg.
(*d*) Experimental, applied research.
(*e*) A hydraulic model of Grand Bay, Newfoundland, was used to determine the lay-out of breakwaters for a newly proposed harbor to accommodate the ferry traffic between Newfoundland and the main land.
(*f*) Complete.

413-09562-330-90

MIRAMICHI CHANNEL STUDY

(*b*) Ministry of Transport.
(*c*) D. H. Willis.
(*d*) Experimental, applied research.
(*e*) A scale model study of the Miramichi Estuary, N. B., to determine the effects of deepening the navigation channel on the flow regime and to define locations of dumping grounds.

UNIVERSITY OF NEW BRUNSWICK, Department of Civil Engineering, Fredericton, N. B., Canada. Professor Dale I. Bray.

414-09569-300-90

CUTOFFS IN GRAVEL-BED RIVERS

(*b*) The National Research Council of Canada.
(*d*) Field investigation, applied research, Master's thesis.
(*e*) Evaluation of technique for determining stability of river reach at a cutoff in a gravel-bed river.

414-09570-300-90

DEVELOPMENT OF SYNTHETIC RATING CURVES FOR GRAVEL-BED RIVERS

(*b*) The National Research Council of Canada.
(*d*) Field investigation, applied research, Master of Engineering report.
(*e*) Development of synthetic rating curves based on detailed field survey data. Three river reaches at hydrometric stations on gravel-bed rivers used for study. Synthetic rating curves are compared with measured rating curves.

414-09571-020-00

DISPERSION IN A RECTANGULAR CONDUIT WITH RELATIVELY LARGE ROUGHNESS ON ONE BOUNDARY

(*c*) Dr. K. S. Davar.
(*d*) Experimental and theoretical, basic research, Doctoral thesis.
(*e*) Variation of the longitudinal dispersion coefficient is to be evaluated for various roughness sizes and spacing.

414-09572-210-90

RESISTANCE TO FLOW IN A RECTANGULAR CONDUIT WITH RELATIVELY LARGE ROUGHNESS ON ONE BOUNDARY

(*b*) The National Research Council of Canada.
(*c*) Dr. K. S. Davar.
(*d*) Experimental and theoretical, basic research, Doctoral thesis.
(*e*) Resistance to flow in a rectangular air duct is evaluated for various roughness sizes and spacing.

ONTARIO HYDRO, 620 University Avenue, Toronto, Ontario, Canada M5G 1X6. Mr. J. B. Bryce, Hydraulic Studies Engineer.

415-07963-340-90

BRUCE GENERATING STATION "A," VACUUM BUILDING

(*b*) Atomic Energy Commission of Canada Limited.
(*c*) Mr. F. B. Schafheitlin, Design Superintendent, Auxiliary Processes, A.E.C.L. Sheridan Park, Ontario, Canada.
(*d*) Experimental; design.
(*e*) A 1:20 scale model of the vacuum building of a 4 x 750 MW nuclear power plant. Model simulates the spray-condensing system built into the vacuum building and is used to develop a design that would automatically release water from the storage tank into the spray pipes in response to the dynamic process triggered by an accidental release of nuclear steam.
(*f*) Test program completed; model inactive.

415-07966-340-73

COLESON COVE GENERATING STATION (LORNEVILLE) – COOLING WATER INTAKE AND OUTFALL

(*b*) New Brunswick Electric Power Commission.
(*c*) Mr. C. W. Turner, Senior Civil Engr., New Brunswick Elec. Power Comm., Fredericton, New Brunswick, Canada, E3B 4X1.
(*d*) Experimental; design.
(*e*) A 1:80 scale model of cooling water intakes and outfalls for a 3 x 300 MW fossil-fired thermal plant located at the Bay of Fundy. Model used to study the most suitable location and design of intakes to assure proper operating conditions for cooling water pumps with regard to wave action, silting and warm water circulation, and the location and type of cooling water outfall to investigate environmental effects.
(*f*) Investigation completed; model inactive.

415-09573-340-00

BRUCE GENERATING STATION "B," COOLING WATER OUTFALL DUCT

(*d*) Experimental; design.
(*e*) A 1:25 scale model of the closed duct used to convey cooling water from the condenser to the open surface outfall channel. Model used to determine design details and performance, i.e., head loss, for maximum economic efficiency.

415-09574-340-00

BRUCE GENERATING STATION "B," COOLING WATER OUTFALL CHANNEL

(*d*) Experimental, design.
(*e*) A 1:60 scale model of the open-surface channel used to return spent cooling water from the plant to Lake Huron. Model used to determine design details and performance, to reduce head loss and to promote effective mixing of the cooling water with the ambient body of water of Lake Huron for quick heat dispersion.

415-09575-340-00

PICKERING GENERATING STATIONS "A" AND "B"

(*d*) Experimental; design.
(*e*) A 1:120 scale model of the condenser cooling water intake and outfall, including the adjacent area of Lake Ontario, affected by the once-through cooling process. Model used to study hydraulic design details of intake and outfall works, to prevent sediment intake, cooling water recirculation and to improve efficiency of heat dispersion of cooling water waste heat.

415-09576-340-00

PICKERING GENERATING STATIONS "A" AND "B" - SPENT FUEL BAY

(*d*) Experimental, operation.
(*e*) An investigation to determine impact velocities in case of accidental and uncontrolled release into the spent fuel bay of a flask containing spent fuel bundles. Model fuel flasks constructed to five scales, ranging from 1:100 to 1:12, to determine an allowance for "scale effects." High speed movie techniques used in analysis.

415-09577-340-00

PICKERING GENERATING STATION "B"

(*d*) Experimental; design.
(*e*) A 1:20 scale model of one condenser cooling water pumpwell. Model used to develop hydraulic design details for acceptable suction conditions.

415-09578-340-00

BRUCE HEAVY WATER PLANT - WATER HANDLING SYSTEM

(*b*) Lummus Company of Canada Limited.
(*c*) Mr. D. Ross, 255 Consumers' Road Unit 2, Willowdale, Ontario, Canada, M2J 4H4.
(*d*) Experimental; design.
(*e*) A 1:50 scale model of the system comprising intake tunnel, forebays, pumps and intake and outfall channels to convey process and cooling water to and from the heavy water extraction facilities. Model used to determine design details and compliance with the exacting performance specifications, as required by the extraction process.

415-09579-340-00

WESLEYVILLE GENERATING STATION - CONDENSER COOLING WATER SYSTEM

(*d*) Experimental; design.
(*e*) A 1:25 scale model comprising the vertical inlet shaft, forebay, pumpwell inlets, condenser outlets, return duct, outfall channel, as well as an internal recirculation duct to release warm water into the forebay under icing conditions and a tempering pumphouse to pump cold water into outfall channel for reduction of temperature of cooling water at the point of return to Lake Ontario. Model used to determine details of hydraulic design and to check cooling water system performance for this 2000 MW oil-fired thermal station.
(*f*) Investigation in progress.

415-09580-340-00

SO_2 SCRUBBER - PILOT PLANT

(*d*) Experimental; design.
(*e*) A 1:20 scale model of the gas intake, spray tower, demister and re-heat sections. Model used to develop the duct layout to obtain even flow distribution in the critical cross-sections.

415-09581-340-00

ONCE-THROUGH CONDENSER COOLING WATER SYSTEMS - INTAKE DEVELOPMENT

(*d*) Experimental; development.
(*e*) A facility to carry out development work of off-shore submerged condenser cooling water intakes for large fossil-fired and nuclear thermal generating stations. Studies aim at developing a number of intake designs with suitable characteristics regarding plant operation and protection of the environment.
(*f*) Facility under construction.

415-09582-050-00

BUOYANT JET STUDIES

(*d*) Experimental; applied research.
(*e*) A model to study the fundamental fluid mechanics in the interaction of a buoyant jet with a cross-current of ambient temperature. Results to be used in the construction of mathematical models of thermal plume structures in once-through condenser cooling water systems.
(*f*) Investigation in progress.

UNIVERSITY OF OTTAWA, Department of Civil Engineering, Hydraulics Laboratory, Ottawa, K1N 6N5, Canada. Dr. Ronald D. Townsend, Laboratory Director.

416-07998-360-00

HYDRAULIC JUMP DOWNSTREAM FROM A SLOT INFLOW

(*b*) National Research Council.
(*d*) Experimental; Master's thesis.
(*e*) In order to reduce the ecological impact of hot wastewater discharges it is a practice at some thermal power stations to mix tempering water with the wastewater in the discharge channel, thereby effecting a reduction in the temperature of the effluent before it discharges into the receiving body. The present research program is an investigation of the hydraulic jump as an efficient mixer of two different temperature streams.
(*f*) Completed.
(*g*) A model, utilizing a 53 ft-long adjustable slope flume, has been constructed in the laboratory in which it is possible to produce a supercritical room temperature main stream with a subcritical, chilled lateral inflow entering the main stream at right angles. Turbulence intensities, Reynolds stresses and temperature distributions have been measured, downstream from the confluence of the two streams, and an attempt is being made to develop a method for locating the jump in the main channel under a comprehensive range of slot inflows.
(*h*) **Rapid Temperature Reduction of Thermal Effluents,** R. D. Townsend, D. L. Egar, *J. Hydraul. Div., ASCE* **101,** HY5, May 1975.

416-07999-220-97

REDUCTION OF SCOUR AT INLET STRUCTURES TO FILTRATION TANKS

(*b*) City of Ottawa, Waterworks Engineering Department.
(*d*) Experimental; applied research for design; M.Eng. thesis.
(*e*) The problem of reducing the amount of scour that takes place in the vicinity of inlet control gates to the filtration tanks of an existing water purification plant facility is to be investigated using a hydraulic model. Flow diffusers, of different geometries, will be considered in combination with a more suitable filter surface material in an attempt to minimize the degree of scour at entry to the tanks.
(*f*) Completed.

416-08000-220-00

A LABORATORY INVESTIGATION INTO DESIGN CRITERIA FOR SUBMERGED PIPELINES CROSSING ALLUVIAL STREAMS

(*d*) Experimental; applied research; Master's thesis.
(*e*) The impending construction of large diameter natural gas and oil pipelines in the Yukon and Northwest Territories will involve the crossing of many streams. The major factor to consider in the design of northern stream crossings is the abnormally high rates of erosion of alluvial deposits associated with severe spring freshets. This project, which involved a laboratory model study, was initiated for the following reasons: (1) A need to obtain more realistic design criteria for submerged river crossings, (2) to provide a theory for estimating minimum depths of cover for a proposed crossing, and (3) to investigate means of improving the stability of the river bed material in the immediate vicinity of a crossing.
(*f*) Completed.

(*g*) The report points out how probability concepts may be used in selecting a safe depth of cover for a submerged pipeline crossing of a stream given a record of flood flows, or even better, a record of centerline bed profiles during flood flows. It was found that the concept of critical shear stress could be used in computing the required depth of cover, given the physical characteristics of the crossing, the flood discharge, and the grain size distribution curve for the bed material. Crushed rock placed immediately upstream and downstream from the pipe was found to enhance pipe stability during flood flows.

(*h*) **A Laboratory Investigation Into Design Criteria for Submerged Pipelines Crossing Alluvial Streams,** D. W. Farley, *M.Eng. Thesis*, Dept. of Civil Engrg., Univ. of Ottawa, Dec. 1971.
Design Criteria for Submarine Pipeline Crossings, R. D. Townsend, D. W. Farley, *J. Hydraul. Div., ASCE* **99,** HY10, Oct. 1973.

416-08002-170-90

SIMILITUDE IN HEAT TRANSFER AT A WATER SURFACE IN A NONUNIFORM FLOW

(*b*) National Research Council of Canada.
(*c*) Professor R. G. Warnock.
(*d*) Experimental basic research for Master's thesis.
(*e*) Purpose of the work is to determine relative importance of modeling parameters for heat transfer at a water surface in a nonuniform flow. It is hoped to apply the information to modeling of ice formation problems.
(*f*) Completed.
(*g*) The goal of the study was to investigate the proper method of simulation of heat transfer problems in a nonuniform, free-surface flow. An experiment was used in which heat flowed over a nonuniform water flow. The variation of the Nusselt number with Froude and Peclet numbers was investigated. The Froude number appeared to be the more important parameter determining the heat transfer. Tests were made over a range of Froude numbers from 0.05 to 0.16.
(*h*) **Similitude in Heat Exchange Processes at a Water Surface in a Nonuniform Flow, P. G. R. Massonnie,** *M.A.Sc. Thesis*, July 1972.

416-09583-390-00

HYDRAULIC PERFORMANCE OF VERTICAL, FLARED INLETS TO SERVICE RESERVOIRS

(*d*) Experimental; Master's thesis.
(*e*) The hydraulic performance of a number of model flared inlets, of different geometries, is being investigated to produce suitable data for the design of prototype structures.

416-09584-870-90

HYDRAULICS OF JUNCTION MANHOLES

(*b*) National Research Council of Canada.
(*d*) Experimental; Master's thesis.
(*e*) Models of different basic arrangements and geometries for stormwater sewer junctions are being investigated with a view to minimizing the head losses across such structures.

416-09585-870-90

MERCURY TRANSPORT BY BED SEDIMENT MOVEMENTS

(*b*) National Research Council of Canada.
(*d*) Experimental, basic research for Master's degree.
(*e*) This study is part of a five-year interdisciplinary study investigating the uptake, release, and subsequent transport of persistent pollutants (particularly mercury) in a section of the Ottawa River near the Capital City. A laboratory flume is being used to investigate the properties of the various types of sedimentary material found in the river bed. Mercury sorption capacities, of different fractions of bed-sediments, are being measured under both static and dynamic conditions. Also pollutant mass transport rates are being measured using a radioactive tracer labeled with ^{203}Hg.
(*g*) Initial field studies have confirmed that the bed-sediments constitute the major source of contamination along the study section (approximately 97 percent of mercury distributed within same).
(*h*) **Mercury Transport by Bed Sediment Movements,** R. D. Townsend, et al., *Proc. Intl. Conf. Transport of Persistent Chemicals in Aquatic Ecosystems*, Ottawa, May 1974.

416-09586-300-90

LATERAL DIFFUSION IN THE OTTAWA RIVER

(*b*) National Research Council of Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Field, basic research for Master's thesis.
(*e*) Determine the diffusion coefficient in the Ottawa River and how it varies with hydraulic conditions.
(*f*) Completed.
(*g*) Point sources of rhodamine-B dye were released in the Ottawa River and dye concentrations measured downstream. The data were used to calculate a diffusion coefficient.
(*h*) **Flow Characteristics and Suspended Material,** R. G. Warnock and co-workers, *Section 3, Distribution and Transport of Pollutants in Flowing Water Ecosystems, Rept. No. 2*, Ottawa River Project, Feb. 1974.
A Field Investigation of the Lateral Turbulent Diffusion Coefficient in the Ottawa River, M. A. Mescal, *M.A.Sc. Thesis*, Dec. 1974.

416-09587-220-90

SUSPENDED SEDIMENT FROM URBAN DEVELOPMENT

(*b*) National Research Council of Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Field and theoretical, basic research for Doctoral degree.
(*e*) Gather data on the production of suspended sediments from land undergoing development and experiencing construction.
(*h*) **Suspended Sediments from Urban Development,** R. G. Warnock, R. G. Lagoke, *Symp. Effects of Man on the Interface of the Hydrological Cycle with the Physical Environment (Erosion in Urban and Rural Environments)*, Celebration of the Tercentenary of Scientific Hydrology, Paris, France, Sept. 9-12, 1974.

416-09588-300-90

SUSPENDED SOLIDS AND VELOCITY DISTRIBUTIONS IN THE OTTAWA RIVER

(*b*) National Research Council of Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Field, applied research.
(*e*) Determine the spatial and temporal variation of suspended solids in the Ottawa River, to determine velocity distributions under different flow conditions for a three-mile reach of river as input to a mathematical model and to investigate local characteristics of velocity distributions.
(*h*) **Suspended Solids and Velocity Distributions in the Ottawa River,** R. G. Warnock, S. I. Khun, *Intl. Conf. Transport of Persistent Chemicals in Aquatic Ecosystems*, Ottawa, Canada, May 1-3, 1974.
Flow Characteristics and Suspended Materials, R. G. Warnock and co-workers, *Section 3, Distribution and Transport of Pollutants in Flowing Water Ecosystems, Rept. No. 2*, Ottawa River Project, Feb. 1974.

416-09589-870-90

TRANSPORT AND REMOVAL OF POLLUTANTS IN SOIL WATER SEEPAGE

(*b*) Environment Canada.
(*c*) Dr. R. G. Warnock.
(*d*) Field, basic research for Doctoral degree.
(*e*) Determine removal of pollutants from the seepage from a septic tile in saturated and unsaturated flow.
(*f*) Completed.
(*g*) In a field investigation the percent of the reduction in concentration of pollutants in septic tile seepage has been

determined under varying environmental conditions. Results represented both saturated and unsaturated flow.

(*h*) **Treatment Through Soil of Septic Tank Effluent,** T. Viraraghavan, R. G. Warnock, *Proc. Intl. Conf. Land for Waste Management*, Ottawa, Oct. 1-3, 1973.
Treatment Efficiency of a Septic Tile System, T. Viraraghavan, R. G. Warnock, *Home Sewage Disposal Symp. Proc., ASAE*, Chicago, Ill., USA, Dec. 8-9, 1974.

416-09590-810-00

PRODUCTION AND TEMPORAL DISTRIBUTION OF SNOWMELT RUNOFF

(*c*) Dr. R. G. Warnock.
(*d*) Field, experimental, basic.
(*e*) Obtain a better understanding of the melting and runoff of snow from a small drainage area. The data will be used for modeling the process.
(*f*) Suspended.
(*h*) **Studies of the Time Distribution of Snowmelt Runoff from a Small Drainage Basin in Ontario,** *Eastern Snow Conf.*, Ottawa, Feb. 8-9, 1974.

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UNIVERSITY OF SASKATCHEWAN, Department of Civil Engineering, Hydraulics Laboratory, Saskatoon, Saskatchewan, Canada. Professor C. D. Smith, Department Head.

417-07891-320-90

SIPHON INLET STRUCTURES

(*b*) National Research Council.
(*d*) Experimental research for M.Sc. thesis.
(*e*) Hydraulic model study of a simplified siphon inlet structure involving a flow transition from a trapezoidal canal to a circular pipe without the use of warped walls.
(*f*) Completed.
(*g*) The proposed design was found to be satisfactory. Discharges and flow profiles were steady and predictable, and head losses were insignificant.

417-09591-390-90

EXPANSIONS AT CONDUIT OUTLETS

(*b*) National Research Council.
(*d*) Experimental research.
(*e*) The efficiency of an abrupt expansion at the free outlet of a circular conduit was studied with a view to possible adaptation to culvert outlets. The length to diameter ratio required to properly recover head and reduce velocity was determined.
(*f*) Completed.
(*g*) For a pipe diameter ratio of $D_1/D_2 = 0.88$ it was found that the full theoretical recovery and corresponding velocity reduction occurred, provided the pipe length after the expansion was at least 1.5 pipe diameters.
(*h*) **Expansion at Conduit Outlets,** C. D. Smith, *Proc. 1st Can. Hydraul. Conf., Can. Soc. Civil Engrg.*, Edmonton, 1973.

417-09592-350-90

STONE PAVED DROP STRUCTURE

(*b*) National Research Council.
(*d*) Experimental research for M.Sc. thesis.
(*e*) Two- and three-dimensional study of the hydraulic performance of a drop structure comprised entirely of stone. Three different stone sizes, four different slopes and two different layer thicknesses were studied. Each structure was tested to failure.
(*f*) Completed.
(*g*) Fourteen structures were tested to failure, and the value of the stability parameter, depth times slope divided by stone diameter, was found to fall within very narrow limits in every case. Design criteria were established.
(*h*) **Cobble Lining for Steep Channels,** C. D. Smith, D. G. Murray, *2nd Can. Hydraul. Conf.*, May 1972.

417-09593-220-68

SEDIMENT YIELD ESTIMATE FROM AN INDEX OF POTENTIAL SEDIMENT PRODUCTION

(*b*) Qu'Appelle Basin Board.
(*c*) Prof. T. M. Wigham.
(*d*) Applied research of an experimental nature.
(*e*) Relate readily available drainage basin properties to potential sediment production. The form of the relationship was that of the Universal Soil-Loss equation modified to take into account the fact that most sediment production comes from snowmelt runoff, and the area contributing to this runoff is variable, but most likely is best represented by the dry drainage area. The estimate of potential sediment production obtained from the relationship developed was then compared to the few sediment flow measurements available.
(*f*) Completed.
(*g*) An index of potential sediment production was obtained from watershed characteristics using a modified form of the Universal Soil-Loss equation. The index was related to the few actual sediment flow measurements available, but the lack of data prevented any firm documentation of the reliability of the method. The method is adjudged to be of value in preliminary design only.

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UNIVERSITY OF TORONTO, Department of Mechanical Engineering, Toronto, Canada M5S 1A4. Professor W. Douglas Baines, Department Chairman.

418-06811-130-00

ENERGY LOSSES IN TWO-PHASE FLOW

(*d*) Experimental and theoretical for Doctoral thesis.
(*e*) Concerns flow of flashing fluid in horizontal circular pipe, to gain insight into development of two-phase single-component flow by investigating pressure gradients, local void fractions and phase velocities. Hot-film anemometer has been direct-connected to computer for innovative data sampling at high frequency.
(*f*) Experimental study complete; thesis in preparation (R. Abel).

418-06817-360-00

TURBULENCE MEASUREMENTS IN WATER

(*c*) Professor H. J. Leutheusser.
(*d*) Experimental; basic research.
(*e*) Evaluation of turbulence parameters in hydraulic jump.
(*f*) Completed.
(*g*) Measurements of turbulence characteristics, air entrainment and flow separation reveal significant effects of condition of inflow onto flow inside jump body.
(*h*) **Le ressaut hydraulique' mesures de turbulence dans la région disphasique,** F. J. Resch, H. J. Leutheusser, *La Houille Blanche* **27**, 4, pp. 279-294, 1972.
Effects of Inflow Conditions on Hydraulic Jump, H. J. Leutheusser, V. C. Kartha, *J. Hydr. Div., ASCE* **98**, HY8, pp. 1367-1385, 1972.
Mesures des tensions de Reynolds dans le ressaut hydraulique, F. J. Resch, H. J. Leutheusser, *J. Hydr. Research, IAHR* **10**, 4, pp. 409-430, 1972.
Bubbly Two-Phase Flow in Hydraulic Jump, F. J. Resch, H. J. Leutheusser, S. Alemu, *J. Hydr. Div., ASCE* **100**, HY1, pp. 137-149, 1974.

418-07461-240-00

AERODYNAMIC OSCILLATIONS OF BLUFF CYLINDERS

(*c*) Professor I. G. Currie.
(*d*) Theoretical and experimental.
(*e*) A basic study intended to better the understanding of the interaction between the fluid flow around an elastically supported body and the dynamic response of the body.

(*g*) A satisfactory explanation for the "double-amplitude" response observed in aeolian vibrations has been developed.
(*h*) **The Response of Circular Cylinders to Vortex Shedding,** I. G. Currie, R. T. Hartlen, W. W. Martin, in *Flow-Induced Structural Vibrations* (ed. Ed. E. Naudascher), Springer-Verlag, pp. 128-142, 1974.

418-07465-860-00

STUDY OF WATER USAGE IN METROPOLITAN TORONTO

(*c*) Professor L. E. Jones.
(*d*) Analytical; applied research for Bachelor's thesis.
(*e*) Daily pumpage data have been computer-plotted and correlated with atmospheric temperature and humidity data.
(*f*) Extension of previous study.
(*g*) Daily water consumption shows very low correlation with relative humidity or with ambient temperature below 55 °F (empirically chosen "interface" between "cold" and "warm"). For "warm" days, however, the correlation between water consumption and ambient temperature is quite significant.
(*h*) **Further Studies of Water Usage in Metropolitan Toronto,** C.-K. D. Hui, *B.A. Sc. Thesis*, Univ. of Toronto, 1975.

418-07468-360-99

ENERGY DISSIPATORS FOR STREAM DIVERSIONS

(*b*) Consulting assignment.
(*d*) Analytical and experimental; applied research.
(*e*) Urban development requires relocation of natural streams and significant energy dissipation.
(*f*) Completed.
(*g*) An innovative design ("multistage weir-pool-orifice energy dissipator") has been developed and model-tested to show substantial advantages and economies. The two units so far constructed have capacities of 10,000 and 14,000 HP, respectively, and the model studies show a capabiltity of up to 100 percent overload.
(*h*) Paper presented to ASCE (1972). Report in preparation.

418-07474-210-00

ZERO-FLOW WATERHAMMER

(*c*) Professor H. J. Leutheusser.
(*d*) Analytical and experimental; basic research for Doctoral thesis.
(*e*) Mechanics of pulse transmission in viscous fluid lines.
(*f*) Completed.
(*g*) Parallel-flow theory of pulse transmission (which fails to provide a satisfactory quantitative prediction of wave decay) is superseded by an extended version of the Iberall model of fluid transients which accounts for elastic as well as inertial effects of the flow boundary.
(*h*) **Pulse Propagation in Distensible Fluid Lines,** D. A. P. Jayasinghe, H. J. Leutheusser, *J. Fluids Engrg., ASME* **96,** 3, pp. 259-264, 1974.

418-07899-010-00

BOUNDARY LAYER SEPARATION ON BLUFF BODIES

(*c*) Professor I. G. Currie.
(*d*) Experimental and theoretical; basic research for Doctoral thesis.
(*e*) The nature of flow in the vicinity of a separation point on a bluff body is under investigation with a view to bettering our understanding of the separation phenomenon.
(*g*) More fundamental information concerning the nature of the separation point has been acquired.

418-07900-200-00

FREE SURFACE FLOW OVER FINITE OBSTACLES

(*c*) Professor I. G. Currie.
(*d*) Experimental and theoretical; basic research for Doctoral thesis.
(*e*) A boundary weighted residual analysis is being applied to the free surface flow over an obstacle on the bottom.
(*g*) The apparent anomalies between linear and non-linear treatments have been clarified.

418-07901-200-99

HYPERBOLIC CURVES FOR OPEN-CHANNEL BENDS

(*b*) Consulting assignment.
(*c*) Professor L. E. Jones.
(*d*) Analytical and experimental; applied research.
(*e*) Model studies of channels with extreme curvature.
(*f*) Further model studies pending.
(*g*) Because of its attractive radius-of-curvature characteristics, the hyperbola shows great promise for use where extremes must be accommodated (wide channel and short radius), as confirmed by model studies. The first prototypes have been constructed.

418-07902-440-00

DE-EUTROPHICATION OF SMALL LAKES

(*b*) Collaborative with Dept. of Zoology.
(*c*) Professor L. E. Jones.
(*d*) Analytical; field investigation.
(*e*) Analysis for a given lake indicates that boat-borne pump of moderate capacity can effect a thermal de-stratification with reasonable time. The resulting instability should then permit a more efficient involvement of the natural agencies of sun and wind.
(*f*) Fieldwork is pending.

418-07903-020-00

INTERMITTENCY IN TURBULENT FLOWS

(*b*) National Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Continuing investigation of the properties of the turbulent/non-turbulent interface at the free edge of shear flows, e.g., boundary layers, wakes, jets and mixing layers. On-line digital sampling and processing techniques are used. Passive contaminants are used to help identify the turbulent field.
(*g*) Generalized method for deciding when fluid motion is turbulent has been studied. Improved detector functions have been derived as a result. Techniques have been applied to a turbulent boundary layer, thermal mixing layer, hot wake and hot jet.
(*h*) **Turbulent/Non-Turbulent Decisions in an Intermittent Flow,** T. B. Hedley, J. F. Keffer, *J. Fluid Mech.* **64,** p. 625, 1974.
Some Turbulent/Non-Turbulent Properties of the Outer Intermittent Region of a Boundary Layer, T. B. Hedley, J. F. Keffer, *J. Fluid Mech.* **64,** p. 645, 1974.

418-07904-480-00

WIND STRUCTURE OVER URBAN AREAS

(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical, field study.
(*e*) Digital sampling and processing of data taken from field stations are used to determine the large-scale structure of wind generated by large buildings. Field sites are chosen so that multi-point, spacetime correlation techniques can be used.
(*g*) Preliminary results show a shift of energy in power spectrum from high to low wave numbers.
(*h*) Doctoral thesis in preparation.

418-09595-060-00

CONTROL OF HOT OR LARGE PLUMESS

(*c*) Prof. W. D. Baines.
(*d*) Experimental and theoretical.
(*e*) Buoyant plumes which are produced by hot, large sources are common in steel foundries and other process industries. The size, velocity and thermal development of these plumes cannot be determined by existing theories which are based on the Boussinesq approximation and a point

source. Studies are under way to determine the characteristics of these plumes and to devise schemes for their control in typical geometrical configurations.

(*g*) A theory for a hot plume has been developed and experimental confirmation is now being attempted. A study of the effectiveness of fume hoods has been completed.

(*h*) **The Flow From a Source of Buoyancy Through an Open Canopy Fume Hood,** M. Bender, *M.A.Sc. Thesis*, Univ. of Toronto, 1974.

418-09596-810-00

RELATIONSHIP OF RAINFALL, RUNOFF AND BASIN CHARACTERISTICS, ROUGE RIVER, ONTARIO, CANADA

(*c*) Professor L. E. Jones.
(*d*) Analytical; applied research.
(*e*) Rainfall and runoff data associated with typical summer storms have been investigated on a fine time-structure basis (hourly) and related to the basin characteristics.
(*g*) Innovative methods of data interpretation have yielded significant information on meteorological-hydrological relationships.

418-09587-020-87

SPREAD OF HEAT AND MOMENTUM IN ASYMMETRICAL TURBULENT FLOWS

(*b*) Institut de Mecanique Statistique de la Turbulence, Marseille, France and National Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Examination of spread of contaminants in free turbulent shear flows with asymmetrical velocity and temperature profiles. Experiments being carried out in mixing layer with jump in temperature and an asymmetrical, partially heated jet.
(*g*) It has been found for the velocity case of an asymmetric wake flow that a relatively large region of "negative production of turbulence" exists. For the case of a partially heated mixing layer the equivalent thermal situation is found also.
(*h*) **An Experimental Investigation of an Asymmetrical Turbulent Wake,** M. D. Palmer, J. F. Keffer, *J. Fluid Mech.* **53,** **p. 593, 1972.**

418-09598-020-90

DISTORTION OF TURBULENT SHEAR FLOWS

(*b*) National Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Examination of gross uniform strain applied to various shear flows, e.g., wakes and mixing layers.
(*g*) Results for a thermal mixing layer indicate that the self-preserving scales do not follow the predicted variation.
(*h*) Doctoral thesis in preparation.

418-09599-210-00

SKIN FRICTION IN UNSTEADY FLOW

(*c*) Professor H. J. Leutheusser.
(*d*) Basic research, experimental and theoretical.
(*e*) Study of the mechanics of energy dissipation in transient flow.
(*g*) U-tube oscillations and establishment-in-time of pipe flow have been studied both experimentally and analytically. Results indicate conclusively that the standard techniques for approximating transient skin friction effects lead to erroneous results.
(*h*) **Frequency-Dependent Friction in Oscillatory Laminar Pipe Flow,** D. A. P. Jayasinghe, M. Letelier, H. J. Leutheusser, *Intl. J. Mech. Sciences*, in press.
Time Dependent Flow Establishment in Long Smooth-Walled Pipes, K, W. Lam, *M.A.Sc. Thesis*, Univ. of Toronto, 1974.

418-09600-870-00

PHYSICAL MODELING OF GASEOUS DISPERSION

(*c*) Professor H. J. Leutheusser.
(*d*) Applied research, experimental.
(*e*) Measurement of contaminant concentration around buildings and topographical features.
(*g*) Using a newly developed fast-acting concentration meter, results have been accumulated which reveal pronounced effects of surface irregularities upon dispersion pattern.
(*h*) **Concentration Meter for Wind Tunnel Studies of Gaseous Dispersion,** J. Motycka, H. J. Leutheusser, *Atmosph. Environment* 6, 12, pp. 911-916, 1972.
Redesign of Refinery Stacks by Wind Tunnel Tests to Meet Changes in Crude Oil Quality, H. J. Leutheusser, J. Motycka, *Paper 74/163, Air Poll. Control Assoc.*, Pittsburgh, Pa., 1974.

418-09601-210-00

WATERHAMMER INTENSIFICATION IN BRANCHING PIPES

(*c*) Dr. G. D. Ransford.
(*d*) Theoretical and experimental.
(*e*) Study of waterhammer resulting from sudden closure of a valve supplied through a pipe with a branch closed by a dead end.
(*f*) Completed.
(*g*) High intensification of the initial shock results from multiple reflections, both in the dead end and against the closed valve. Intensification may be of the order of 10 for small dead-ended pipes located at certain critical distances along the main pipe, a result that must be of significance in the design of pressure tappings.
(*h*) **Waterhammer Intensification in Branching Pipes,** V. Jovich, *M.A.Sc. Thesis*, Univ. of Toronto, 1973.

418-09602-350-00

SPILLWAY NAPPE FLUTTER

(*c*) Dr. G. D. Ransford.
(*d*) Theoretical, using prototype test data.
(*e*) Study of the mechanics of spillway nappe flutter, specifically as occurring on Black Canyon Dam spillway, in the United States.
(*g*) Study of the full-scale flutter results shows conclusively that the basic mechanism causing flutter is the action of the pressure on the underside of the nappe where this springs clear of the spillway structure. Model tests on flutter must be misleading in this respect, because under laboratory conditions, surface tension plays a preponderant role, which is absent on prototype spillways.

418-09603-210-00

SLOTTED INTAKE DESIGNED FOR CONSTANT FLOW PER UNIT LENGTH

(*c*) Dr. G. D. Ransford.
(*d*) Experimental verification of theory.
(*e*) Study of inflow into a pipe having a slot of variable thickness designed according to momentum theory so as to produce constant inflow per unit length of slot.
(*f*) Completed.
(*g*) Good corroboration of theory originally developed by A. Craya.
(*h*) **Slotted Pipes Giving Constant Inflow Per Unit Length,** A. Kohen, *M. Eng. Project Rept.*, Univ. of Toronto, 1974.

UNIVERSITY OF WATERLOO, Department of Chemical Engineering, Waterloo, Ontario, Canada N2L 3G1. Professor M. Moo-Young.

419-09604-200-90

CHARACTERIZATION OF AERATION-INHIBITION BY SURFACTANTS IN OPEN-CHANNEL FLOW

(*b*) National Research Council of Canada.
(*d*) Experimental applied research.
(*e*) The inhibition effects of surfactant-contaminants on oxygen transfer in the aeration of flowing bodies of water are being quantified in terms of the hydrodynamic and physico-chemical properties of the system. The application of surface-baffles in open-channel conduits to overcome these adverse effects are being examined.
(*g*) Results available in publications.
(*h*) **Gas Absorption Rates at the Free Surface of a Flowing Water Stream,** M. Moo-Young, M. Shoda, *I.E.C. Process Design/Develop.* **12,** p. 410, 1973.

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UNIVERSITY OF WATERLOO, Department of Civil Engineering, Waterloo, Ontario, Canada N2L 3G1.

421-09605-310-00

RESERVOIR OPERATION DURING FLASH FLOODS

(*c*) Professor N. Kouwen.
(*d*) Field investigation, applied research.
(*e*) The work examines the utility of a direct access computer program with radar precipitation inputs in forecasting stream flow during flash floods.
(*h*) **Watershed Modeling Using a Square Grid Technique,** *Proc. Canad. Hydraul. Conf.*, Edmonton, Alberta, May 1973.

421-09606-200-00

DISPERSION EFFECTS ON REAERATION IN STREAMS

(*c*) Professors G. J. Farquhar and N. Kouwen.
(*d*) Theoretical and experimental, thesis.
(*e*) Analytical methods are sought to define the two- and three-dimensional effects of flow and river geometry on reaeration and resultant DO and BOD in streams.
(*g*) Critical conditions may not be found using one-dimensional models to check if water quality criteria would be met in new projects.

421-09607-210-00

SLAMMING OF HYDRAULIC CHECK VALVES

(*c*) Professors N. Kouwen and David Weaver of McMaster University, Hamilton, Ontario, Canada.
(*d*) Theoretical and experimental; thesis.
(*e*) Methods are sought to reduce the harmful effects of slamming of closing check valves in water lines.
(*h*) **On the Hydroelastic Vibration of a Hydraulic Check Valve,** D. S. Weaver, N. Kouwen, W. M. Mansour, *Proc. Intl. Symp. Flow Induced Vibrations, Paper C2*, Univ. of Karlsruhe, Aug. 1972.

421-09608-860-00

WATER QUALITY BEHAVIOR IN ICE COVERED RIVERS

(*c*) Professors E. McBean and G. J. Farquhar.
(*d*) Theoretical and field investigation; thesis.
(*e*) The changes in velocity profile, the potential alteration in depositional patterns and the effects of breaks in ice covers are a few of the factors which preclude direct utilization of non-ice relationships in the presence of ice. The intent of this research is to identify, and define, the role of the essential features affecting the water quality response under ice.

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UNIVERSITY OF WATERLOO, Department of Mechanical Engineering, Waterloo, Ontario, Canada N2L 3G1. Professor D. J. Burns, Department Chairman.

422-09609-020-90

TURBULENT SHEAR FLOWS (SINGLE PHASE)

(*b*) National Research Council of Canada.
(*c*) Professors E. Brundrett, W. B. Nicoll and A. Strong.
(*d*) Basic experimental and analytical.
(*e*) Basic turbulence measurements are being taken on the low speed wind tunnel (3-ft wide x 12-ft long test section) with variable wall heat transfer, wall mass transfer and pressure gradient. An analytical work includes a mixing length proposal for mass transfer and some numerical modeling.
(*h*) **Heat and Mass Transfer in an Incompressible Turbulent Boundary Layer,** E. Brundrett, W. B. Nicoll, A. B. Strong, *Trans. ASME J. Heat Trans.* **94,** 1972.
Mixing Length Distributions in the Near-Wall Region of Transpired Turbulent Boundary Layers, Watts, Brundrett, Nicoll, Strong, *ASME J. Fluids Eng.* **96,** 1974.
Design and Construction of a Wind Tunnel for Mass Transfer Studies in Incompressible Boundary Layers, Watts, Brundrett, Nicoll, Strong, *ASME-CSME Fluids Eng. Conf. Paper 74-FE-30.* Also *ASME J. Fluids Engrg.*, 1975.

422-09610-270-90

BLOOD OXYGENATION

(*b*) National Research Council of Canada, and Ontario Heart Foundation.
(*c*) Professor A. B. Strong.
(*d*) Experimental development of an artificial lung, using principle of rotating Couette Flow.
(*e*) Basic measurements of oxygen transfer efficiency as a function of flow rate and rotational speed.
(*h*) **Blood Oxygenation Using the Principle of Rotating Couette Flow,** A. Strong, W. Zingg, (Toronto Sick Childrens Hospital) *Proc. 5th Can. Med. and Biolog. Engrg. Soc.*, 1974.

422-09611-130-90

TURBULENT SHEAR FLOW (TWO-PHASE)

(*b*) National Research Council of Canada; Atomic Energy of Canada.
(*c*) Professor W. B. Nicoll.
(*d*) Analytical correlation and prediction for transient, fixed pressure drop water-steam diabatic flow.
(*h*) **A General Technique for the Prediction of Void Distributions in Non-Steady Two-Phase Forced Convection,** W. Hancox, W. Nicoll, *Intl. J. Heat Mass Transfer* **14,** 1971.
Prediction of Time Dependent Two-Phase Flows, W. Hancox, W. Nicoll, *Proc. Intl. Symp. Two-Phase Flows*, Haifa, 1971, also *Recent Advances in Heat and Mass Transfer* **VI,** 1972.

422-09612-210-90

FLOW IN A RECTANGULAR DUCT BEND

(*b*) National Research Council of Canada.
(*c*) Prof. J. H. G. Howard.
(*d*) Experimental and analytical.
(*e*) Flow measurement has been carried out on the end-wall of a 1-ft x 4-ft duct bend with adjustable side wall permitting different streamwise pressure gradients. Measurements in the side wall boundary layer and in other duct bends will be continued. Flow prediction methods are being developed and evaluated for flow analysis in duct bends and other shapes typical of turbomachinery passages.
(*h*) **A Zero-Streamwise-Pressure-Gradient, Three-Dimensional Turbulent Boundary Layer in a 90 Degree Curved Rectangular Duct,** Young, Howard, Jerie, *Trans. Can. Soc. for Mech. Eng.* **1,** 2, pp. 87-96, 1972.
A Wall-Skew-Angle Correlation for Flow in Curved Ducts, Young, Howard, *CSME Paper 73-CSME-74*, 1974.

422-09613-130-90

THE FLUID MECHANICS OF DUSTS AND AEROSOLS

(*b*) National Research Council of Canada.
(*c*) Professor G. M. Bragg.
(*d*) Experimental and analytical.
(*e*) Basic flow mechanisms involved in the particulate measurement process are under study and analysis is being undertaken of collection mechanisms in pollution control machinery. The study is particularly concerned to develop analytical models of impactors, membrane filters, industrial filters and cyclones.

422-09614-630-90

UNSTEADY AERODYNAMICS OF TURBOMACHINE BLADES

(*b*) Defense Research Board.
(*c*) Professor R. Skarecky.
(*d*) Experimental and analytical.
(*e*) Measurement and analysis of the passage of the flow field generated by the rotor of an axial turbomachine through the subsequent stator to establish correlations between velocity, pressure and angle fluctuations and resulting unsteady forces on the blades.
(*g*) Test facility and measuring methods involving on-line sampling and averaging have been developed.

WESTERN CANADA HYDRAULIC LABORATORIES LTD., 1186 Pipeline Road, Port Coquitlam, B. C., Canada. Mr. Duncan Hay, Director.

423-09615-470-90

MODEL STUDIES OF FRENCH CREEK HARBOUR BREAKWATER

(*b*) Department of Public Works, Canada.
(*d*) Experimental for design and operation.
(*e*) Determine the degree of protection from north-east waves achieved by additions or alterations to the existing breakwater. The improvements were considered relative to cost of the changes.
(*f*) Completed.

423-09616-470-90

MODEL STUDIES OF VANTERM DEVELOPMENT

(*b*) National Harbours Board of Canada; Port of Vancouver.
(*d*) Experimental for design and operation.
(*e*) The study examined the influence of the Vanterm wharf development on tidal currents at adjacent piers with emphasis on ship berthing operations.
(*f*) Completed.

423-09617-850-90

HYDRAULIC MODEL STUDIES OF FISH HOLDING TANKS

(*b*) Fisheries Research Board, Vancouver Laboratory.
(*d*) Experimental for design and operation.
(*e*) The study was conducted using a transparent plastic model of a fish holding tank using refrigerated sea water, typical of those used by fish packers for transporting salmon. Purpose of tests was to examine flow conditions in existing tanks; determine the influence of loading, location of discharge, suction and screening on circulation; to effect improvements in efficiency and establish guidelines for design.
(*f*) Completed.

423-09618-330-90

HYDRAULIC MODEL STUDIES OF PHASE 3, TRIFURCATION SILTATION AND FRASER SURREY DOCK EXTENSION

(*b*) Department of Public Works, Canada.
(*d*) Experimental for design and operation.
(*e*) Reproduce the pattern of sediment transport in the Fraser River at New Westminster; to devise remedial measures to reduce infill behind the training wall and examine the effect of the proposed dock extension on existing training works.
(*f*) Completed.

423-09619-870-97

HYDRAULIC MODEL STUDIES OF DIFFUSER OUTLET FOR ANNACIS ISLAND SEWAGE TREATMENT PLANT

(*b*) Greater Vancouver Sewerage and Drainage District.
(*d*) Experimental for design and operation.
(*e*) It was required to determine the best location for the diffuser with respect to river bed characteristics and navigational requirements and to hydraulically design the diffuser system for optimum dilution of the effluent at various water levels.
(*f*) Completed.

423-09620-350-75

HYDRAULIC MODEL STUDIES OF MICA PROJECT TAILRACE COFFERDAM AND WORK AREA

(*b*) Crippen Engineering Ltd., North Vancouver, B. C.
(*d*) Experimental for design and operation.
(*e*) Model studies were conducted to test the stability of a proposed cofferdam and work area developed as a more economical alternative to a previous design tested in December 1971.
(*f*) Completed.

423-09621-350-75

HYDRAULIC MODEL STUDIES OF MISSI FALLS CONTROL STRUCTURE

(*b*) Crippen Acres Limited, Winnipeg, Manitoba.
(*d*) Experimental for design and operation.
(*e*) The approach and tailrace conditions associated with flows through the Missi Falls control structure were examined with a view to modifying the preliminary approach channel, determining location and length of a training groin in the channel, selecting location and size of rip rap protection and developing a method of preventing ice from buffeting pier tails on downstream face of gates.
(*f*) Completed.

423-09622-340-96

HYDRAULIC MODEL STUDIES OF SEVEN MILE PROJECT, PEND D'ORIELLE RIVER, B. C.

(*b*) B. C. Hydro and Power Authority.
(*d*) Experimental for design and operation.
(*e*) Compare three alternative hydraulic structure designs and select that most suited to site; to assess spillway and penstock intake approach conditions, tailwater levels and scour conditions over a range of discharges.
(*f*) Completed.

423-09623-470-90

MODEL STUDIES OF STEVESTON HARBOUR, FRASER RIVER, B. C.

(*b*) Department of Public Works, Canada.
(*d*) Experimental for design and operation.
(*e*) Evaluate the changes in flow and sediment deposition patterns and in tidal flushing action which could arise from the proposed plan to enlarge Steveston Island and incorporate an additional harbor entrance; to determine the best alignment for the entrance and to establish a suitable fill line along the main channel side of Steveston Island.
(*f*) Completed.

423-09624-300-70

MODEL STUDIES OF THE INFLUENCE OF DREDGING LARGE QUANTITIES OF MATERIAL FROM THE FRASER RIVER

(*b*) Dillingham Corporation Canada Ltd., North Vancouver, B. C.
(*d*) Experimental for design and operation.
(*e*) Flume studies and mathematical models were used to examine the effect of dredging 3,000,000 cubic yards of fill from sites adjacent to Port Mann Bridge near New Westminster, B. C. Recommendations were made for safe and economic dredging locations and examination made of changes in river currents, velocities, migration of the borrow holes and the effect on stability of the river bed.
(*f*) Completed.

423-09625-410-75

ASSESSMENT OF FORESHORE CHARACTERISTICS, JERICHO PARK, VANCOUVER, B. C.

(*b*) Bains Burroughs and Hanson.
(*d*) Field investigation.
(*e*) Identify historical and existing foreshore characteristics and to suggest measures to improve and maintain quality of the beaches at Jericho Park.
(*f*) Completed.

423-09626-340-75

MODEL STUDIES OF CIRCULATING WATER COOLING POND, SUNDANCE THERMAL STATION

(*b*) Montreal Engineering, Calgary.
(*d*) Experimental for design and operation.
(*e*) Model studies examined the distribution of surface flow throughout the cooling pond and investigated measures to develop a uniformly distributed flow. Consideration was given to gravitational and momentum effects only in determining flow pattern.
(*f*) Completed.

423-09627-340-75

HYDRAULIC MODEL STUDIES OF COOLING POND DISCHARGE STRUCTURE

(*b*) Montreal Engineering Company Limited, Calgary, Alberta.
(*d*) Experimental for design and operation.
(*e*) A model of Sundance Thermal Power Station discharge gates and cooling pond was used to rate the radial gates, investigate gate approach conditions and hydraulic jump and wave heights generated in the canal.

423-09628-300-90

MODEL STUDIES OF BORROW PITTS IN NORTH ARM, FRASER RIVER, B. C.

(*b*) Department of Public Works, Canada.
(*d*) Experimental for design and operation.
(*e*) Flume and mathematical models were used to investigate the possible migration of particular borrow pits in the North Arm, the rate of infill into the borrow hole and the effect on currents, velocities and river bed profiles.
(*f*) Completed.

423-09629-360-70

MODEL STUDIES OF STILLING BASIN DESIGN

(*b*) Chemco (Africa) Incorporated, New York.
(*d*) Experimental for design and operation.
(*e*) Study investigated methods of improving flow conditions associated with proposed sea water intake for the Sonatrach LNG Plant in Arzow, Algeria. Problems associated with high velocities in conduit and stilling basin and transient surge conditions following simultaneous failure of all operating pumps were investigated.

423-09630-350-96

MODEL STUDIES OF SEVEN MILE PROJECT, PEND D'ORIELLE RIVER, B. C.

(*b*) B. C. Hydro and Power Authority.
(*d*) Experimental for design and operation.
(*e*) Preliminary model studies determined the arrangement and type of spillway. Current studies are to refine hydraulic design, to investigate the diversion works and river closure procedure and to confirm the stability of various construction fills proposed.

423-09631-350-75

MODEL STUDIES OF POPLAR SPILLWAY, MILDRED LAKE PROJECT

(*b*) Underwood McLellan and Associates Ltd., Edmonton, Alberta.
(*d*) Experimental for design and operation.
(*e*) Study was conducted into the performance of spillway crest, shute and spilling basin required to divert Beaver Creek into Poplar Creek. It assessed the effect of varying dimensions and shape of the structures to produce the most economical design which would ensure stability at maximum flows.

423-09632-350-96

MODEL STUDIES OF NOTIGI CONTROL STRUCTURE

(*b*) Manitoba Hydro, Winnipeg, Manitoba.
(*d*) Experimental for design and operation.
(*e*) The tests were conducted to achieve an economic and hydraulically efficient approach and tailrace layout; to examine erosion potential and resultant scour deposition in the excavated rock tailrace channel; to examine potential ice problems and to rate the capacity of the structure.
(*f*) Completed.

423-09633-220-90

STUDY OF NORTH ARM AND STURGEON BANK BORROW HOLES

(*b*) Department of Public Works, Canada.
(*d*) Experimental for design and operation.
(*e*) Investigations were made on the basis of a previous model study to predict the migration of three proposed borrow holes and to extend the previous study to examine effects of the borrow holes on the foreshore of Sturgeon Bank and Point Grey Beaches.

THE UNIVERSITY OF WESTERN ONTARIO, Department of Applied Mathematics, Faculty of Science, London 72, Ontario, Canada. Professor J. H. Blackwell, Department Chairman.

424-07995-030-90

TIME DEPENDENT AND STEADY VISCOUS FLUID FLOW

(*b*) National Research Council of Canada.
(*c*) Professor S. C. R. Dennis.
(*d*) Theoretical.
(*e*) Properties of the initial and steady flow of a viscous fluid past a sphere, a circular cylinder, an elliptic cylinder, a parabolic cylinder and a flat plate have been calculated using semi-analytic and numerical methods of solution of the Navier-Stokes equations. The solutions obtained are valid for various ranges of the Reynolds number, depending upon the problem concerned. A study has also been made of the boundary-layer flow in a shock tube, and the most recent project under investigation is concerned with the steady flow in coiled helical tubes of various cross-sections. The objects of the project are to understand the physical nature of the flows concerned, and also to develop numerical techniques of solving the Navier-Stokes equations.

(*h*) **Numerical Solutions for Time-Dependent Flow Past an Impulsively Started Sphere,** S. C. R. Dennis, J. D. A. Walker, *Phys. Fluids* **15**, pp. 517-525, 1972.
The Boundary Layer Over an Impulsively Started Semi-Infinite Flat Plate, S. C. R. Dennis, *J. Inst. Math. Applics.* **10**, pp. 105-117, 1972.
Unsteady Heat Transfer in Boundary-Layer Flow Over a Flat Plate, S. C. R. Dennis, in *Recent Research on Unsteady Boundary Layers* **I**, Laval Univ. Press, pp. 379-403, 1972.
The Boundary Layer in a Shock Tube, J. D. A. Walker, S. C. R. Dennis, *J. Fluid Mech.* **56**, pp. 19-47, 1972.
The Initial Flow Past an Impulsively Started Circular Cylinder, W. M. Collins, S. C. R. Dennis, *Quart J. Mech. Appl. Math.* **26**, pp. 53-75, 1973.
The Numerical Solution of the Vorticity Transport Equation, S. C. R. Dennis, *Lecture Notes in Physics* **19**, pp. 120-129, 1973.
Flow Past an Impulsively Started Circular Cylinder, W. M. Collins, S. C. R. Dennis, *J. Fluid Mech.* **60**, pp. 105-127, 1973.
Heat Transfer From a Sphere at Low Reynolds Numbers, S. C. R. Dennis, J. D. A. Walker, J. D. Hudson, *J. Fluid Mech.* **60**, pp. 273-283, 1973.
Studies of Symmetrical and Asymmetrical Viscous Flows Past Impulsively Started Cylinders, A. N. Staniforth, *Ph.D. Thesis*, Univ. of Western Ontario, 1973.
Steady Viscous Flow Past a Parabolic Cylinder, J. D. Walsh, *Ph.D. Thesis*, Univ. of Western Ontario, 1973.
Symmetrical Flow Past a Uniformly Accelerated Circular Cylinder, W. M. Collins, S. C. R. Dennis, *J. Fluid Mech.* **65**, pp. 461-480, 1974.

424-07996-020-90

DISPERSION IN TURBULENT SHEAR-FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. P. J. Sullivan.
(*d*) Theoretical and experimental.
(*e*) An analysis of experimental data on the motion of small spheres within turbulent shear flow using a Lagrangian frame of reference is carried out. The purpose is to test previously derived theory and to gather basic information that is germane to the dispersion mechanism of this type of flow. A numerical simulation, using a Markovian type model, has been successfully used to describe dispersion of a passive scalar in two-dimensional shear flows. With the Lagrangian data this simulation will be modified and extended to include more general flow situations. Experimental work on the longitudinal dispersion of dye in a turbulent pipe flow is being carried out to assess the three stage dispersion model. An 1100-foot long one-inch diameter pipe is being used.
(*h*) **Instantaneous Length and Velocity Scales in Turbulent Shear Flow,** *Advances in Geophysics* 18, pp. 213-223, 1974.
The 4/3rds Law of Relative Dispersion, *Mem. Soc. Roy. Sci. Liege* **VI**, 1974.

424-07997-010-90

THREE-DIMENSIONAL BOUNDARY LAYER THEORY

(*b*) National Research Council of Canada.
(*c*) Dr. M. Zamir.
(*d*) Theoretical.
(*e*) The work is aimed at a reconstruction of boundary layer theory so as to accommodate three-dimensional boundary layers within its scope. The main feature of the approach is the use of tensor analysis to rederive the boundary layer equations in a form which is independent of the coordinate system. Three-dimensional boundary layers are of utmost importance since they arise in a wide variety of practical situations such as the flow in rivers and channels of non-circular cross-section.
(*h*) **On The Corner Boundary Layer With Favourable Pressure Gradient,** *Aeronaut. Quart.* **XXIII**, 1972.
Further Solution of the Corner Boundary Layer Equations, *Aeronaut. Quart.* **XXIV**, 1973.

424-09634-400-00

THEORETICAL STUDY OF THE SALINITY AND FLOW PATTERN IN ESTUARIES

(*c*) Dr. H. Rasmussen.
(*d*) Theoretical.
(*e*) A theoretical study of the salinity distribution and the general flow pattern in estuaries is in progress. An approximate steady two-dimensional model has been derived for slightly stratified estuaries and is now being analysed using Galerkin's method.
(*h*) **On Flow in Estuaries, Part I. A Critical Review of Some Studies of Slightly Stratified Estuaries,** H. Rasmussen, J. B. Hinwood, *La Houille Blanche* **209**, pp. 377-395, 1972. **Part II. A Slightly Stratified Turbulent Flow,** *La Houille Blanche* **209**, pp. 396-407, 1972. **Part III, Derivation of General and Breadth Integrated Models,** *La Houille Blanche* **212**, pp. 319-337, 1973.

UNIVERSITY OF WINDSOR, Department of Mechanical Engineering, Windsor, Ontario, Canada. Prof. W. G. Colborne, Chairman, Graduate Studies, Department of Mechanical Engineering.

425-09635-290-90

DIFFUSERS WITH INLET SWIRL

(*b*) National Research Council of Canada.
(*c*) Dr. K. Sridhar.
(*d*) Theoretical; basic research for Ph.D.
(*e*) The work done so far on diffusers is experimental. The aim is now to develop an analytical method for flows in diffusers with inlet swirl.
(*h*) **Effect of Inlet Swirl and Wall Layer Thickness on the Performance of Equiangular Annular Diffusers,** R. Coladipietro, *M.A.Sc. Thesis*, Univ. of Windsor, 1974.
Effects of Inlet Flow Conditions on the Performance of Equiangular Annular Diffusers, R. Coladipietro, J. H. Schneider, K. Sridhar, *Paper No. 73-CSME-84, CSME-ASME Fluids Engrg. Conf.*, Montreal, May 1974.

425-09636-600-90

BISTABLE FLUIDIC AMPLIFIERS

(*b*) National Research Council of Canada.
(*c*) Professor W. G. Colborne.
(*d*) Experimental, basic research for bistable amplifiers. The mechanism of switching in a bistable amplifier is also being studied by investigating the characteristics of the separation bubble. By developing an accurate model it is hoped that accurate predictions of switching time can be made for a variety of configurations and flows.
(*h*) **Splitter Switching in Bistable Fluidic Amplifiers,** C. J. Williams, W. G. Colborne, *CSME Paper No. 73-CSME-83, EIC Accession No. 1541, ASME-CSME Fluids Engrg. Conf.*, Montreal, Quebec, May 13-15, 1974.

425-09637-600-90

ACOUSTICALLY CONTROLLED TURBULENCE AMPLIFIERS

(*b*) National Research Council of Canada.
(*c*) Dr. K. Sridhar.
(*d*) Experimental, theoretical and basic research for M.A.Sc. and Ph.D.
(*e*) Develop a design procedure for shrouded acoustically controlled turbulence amplifiers.
(*h*) **An Investigation of Acoustically Controlled Turbulence Amplifiers,** G. W. Rankin, *M.A.Sc. Thesis*, Univ. of Windsor, 1974.
An Investigation of the Dynamic Response of an Acoustically Controlled Turbulence Amplifier, G. W. Rankin, K.

Sridhar, *Paper B-1*, *Proc. 6th Cranfield Fluidics Conf.*, Cambridge, England, Mar. 1974.

425-09638-020-00

REYNOLDS STRESSES IN STRAINED FLOWS

(*c*) Dr. H. J. Tucker.
(*d*) Experimental.
(*e*) Determination of Reynolds stresses in a variety of pure strain fields in yielding information which is useful in general calculation procedures for turbulent flows.

SUBJECT INDEX

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA SHEET**	1. PUBLICATION OR REPORT NO. NBS SP-443	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE Hydraulic Research in the United States and Canada, 1974 HYDRAULIC RESEARCH IN THE UNITED STATES AND CANADA, 1974	5. Publication Date June 1976 6. Performing Organization Code
7. ~~AUTHOR(S)~~ CO-EDITORS Gershon Kulin and Pauline H. Gurewitz	8. Performing Organ. Report No.
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234	10. Project/Task/Work Unit No. 2130170 11. Contract/Grant No.
12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)* Same as 9.	13. Type of Report & Period Covered Final 14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number: 73-60019

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1973-1974 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries

18. AVAILABILITY [X] Unlimited	19. SECURITY CLASS (THIS REPORT) UNCLASSIFIED	21. NO. OF PAGES 359
[ ] For Official Distribution. Do Not Release to NTIS [X] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13. 10:443 [ ] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151	20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. Price $4.15

USCOMM-DC 29042-P74

☆U.S. GOVERNMENT PRINTING OFFICE: 1976 210-801/289 1-3

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